

**REFORMING THE AIR TRAFFIC CONTROL SYSTEM  
TO PROMOTE EFFICIENCY AND REDUCE DELAYS**

**Prepared for the Council of Economic Advisers**

**by**

**Dorothy Robyn**  
*The Brattle Group*

**In Association with GRA, Incorporated**

**October 29, 2007**

## SUMMARY

Business Week's recent cover story, "Fear and Loathing at the Airport," was notable in part for pointing the finger of blame for flight delays directly at the federal government. It belongs there: contrary to popular opinion, flight delays are not the fault of airline overscheduling, bad weather or antiquated radar. Delays are the fault of flawed public policy.

Our nation's air traffic control (ATC) system has not kept up with the explosive growth in air travel unleashed by airline deregulation, and delays are just the most visible symptom. Federal policy is directly to blame. To paraphrase James Carville, "It's the incentives, stupid."

Problem one is governance. Although the job of keeping aircraft separate must be regulated for safety, it is not inherently governmental. To the contrary, it is a 24/7 high-tech service "business" trapped in a command-and-control federal bureaucracy. In an effort to allow ATC to operate more like a business, it was restructured as a separate unit within the FAA in 2004. The Air Traffic Organization (ATO) has made enormous strides toward becoming more performance-based and customer-oriented. But severe constraints remain, and congressional micromanagement, which the ATO structure was never designed to address, is still pervasive. Most economists believe that ATC should be moved outside of the traditional government bureaucracy altogether. In addition to the efficiency benefits, this would enhance safety by making the ATO independent from FAA regulators—a key but often overlooked consideration.

Short of moving the ATO out of the FAA, there are steps the government can take to increase user input, and the Administration's proposed advisory board is an excellent start. In addition, the FAA could reestablish the ATC Subcommittee to its Management Advisory Committee, and provide more disclosure on ATO spending on capital and operations.

Problem two is financing. The mechanism used to finance ATC (passenger taxes, principally) directly encourages overuse of scarce capacity. First, airlines pay for ATC capacity only indirectly, through passenger taxes. Moreover, a small aircraft contributes less in taxes than a large one, even though it costs the ATC system about the same to serve them (size doesn't matter). For example, a 140-seat Airbus A320 flying from Denver to Phoenix contributes \$1498 in taxes whereas a 50-seat regional jet (RJ) pays only \$502. That partly explains why the use of RJs has more than tripled since 2000. Airlines are providing what customers want—more frequency; but government policy lets carriers reap the benefits without paying the cost.

Most important, the current funding system ignores the congestion costs that additional flights impose on other travelers. Because users are not charged their full cost (and because airlines pay only indirectly), they use the ATC system inefficiently.

The weight-based landing fees imposed by local airports—in keeping with their understanding of ambiguous and outdated federal policy—have the same perverse effect as ATC taxes. They ignore the large costs that delays impose on others at a congested airport—costs to which small and large aircraft contribute in roughly equal measure.

In short, delays are a direct result of the government’s perverse system of charging for aviation infrastructure. Airline overscheduling is a classic tragedy of the commons, and current financing mechanisms not only permit the equivalent of overgrazing—they promote it.

Replacement of the current ATC financing mechanism with efficient (marginal cost) pricing would be the single most effective step the federal government could take to reduce delays and improve the air traffic system. In the short run, when supply is fixed, prices would provide an incentive for more efficient use of scarce air traffic control capacity (allocative efficiency). This would reduce delays by discouraging inefficient uses—flights for which aircraft operators don’t value the capacity enough to pay its cost. Prices would also encourage more efficient provision of ATC services by the FAA (productive efficiency). Among other things, the FAA could offer, and customers could purchase, the services that best met their needs, as opposed to the current, one-size-fits-all. In the long run, a system of prices would encourage efficient investment (investment efficiency)—a key benefit as the FAA moves to a next-generation system.

Although the Administration’s user fee proposal is a step in the right direction, the FAA has neglected to make the efficiency case for user charges. Most puzzling has been the agency’s failure to explain that the current financing system contributes directly to delays—something few Members of Congress understand. Instead, the FAA has argued that user fees are a more stable source of revenue than taxes, and thus key to funding the next-generation air traffic system. Not surprisingly, few Members have been persuaded by the revenue stability argument.

An alternative to pricing the airways—and one in which there is more congressional interest—is congestion pricing of runways, either through slot auctions or administratively set prices. Congestion pricing could reduce delays in the near term. To facilitate it, DOT needs to revise its Rates and Charges Policy and it may want to provide seed funding for local experiments.

FAA ground delay programs (GDPs) offer a particularly good opportunity to improve on the current allocation of scarce capacity. The simplest change would be administrative: instead of making initial GDP “slot” assignments on a first-come-first-served basis, as it does now, the FAA could assign slots based on aircraft size or number of passengers, thereby reducing passenger delays by what could be a significant amount. Alternatively, it could facilitate a blind spot market, to allow airlines to buy and sell GDP slots based on the marginal value of a reduction in the delay faced by their flights (current policy allows just swaps and only on a limited basis). A spot market could operate either *ex ante* or on the day of operations. In theory, a market would be more efficient than an administrative fix, but there are a number of challenges to making it work. Yet another alternative would be for the FAA to sell the equivalent of “non-interruptible” service—to a particular airport at a given time—in advance of a ground delay.

The opportunities for markets and competition will only increase as satellites and sophisticated avionics allow individual aircraft to assume more of the responsibility for aircraft separation. In many cases, providers of next-generation equipment and applications will be able to transact directly with users over price and service. If users pay the private provider directly, the market will determine where and when deployment of the service or equipment makes sense. Moreover, service providers, including local airports, will have an incentive to subsidize equipage.

There are two key implications for government. First, although the need for an ATO-type provider will remain in a next-generation system, the safety and efficiency case for separating it from the FAA will be even stronger. The safety argument is particularly important: the ATO will be a highly stressed environment as it undergoes profound technological change; separation of regulatory oversight will be critical to preserving safety margins.

Second, in addition to regulating safety, the federal government's other principal role will be to set standards that facilitate private competition in services and equipment, including performance standards and technical standards to ensure that equipment is interoperable. In addition, it may be helpful for government to set the financial equivalent of technical standards. By making data on system costs transparent and widely available, the FAA could promote competition in the provision of services and equipment.

The federal government's program to move to this next-generation system, NextGen, is intended to triple capacity by 2025 at a cost of \$40-45 billion, including the cost of equipage. But the approach is highly centralized and technology-centric, and the goal is an ambitious Big Bang transformation that would deliver benefits only at the end of a transition measured in "epochs." In these and other respects, NextGen seems to embody much of what is wrong with the current, command-and-control, one-size-fits-all system. An obvious question is: why will NextGen be any more successful than FAA modernization?

An alternative vision of NextGen calls for delivering targeted improvements in specific regions that users want and are willing to pay for—and doing so in the near and medium term. Carriers are already investing in next-generation technologies in settings where they can capture the benefits. In addition to providing the necessary ground infrastructure, the FAA can facilitate that kind of investment by allowing greater private sector participation (*e.g.*, development of precision routings) and by encouraging airports to take responsibility for next-generation infrastructure. In the aggregate, these decentralized, demand-led projects could add up to a kind of "fast lane" for equipped aircraft in selected airspace—a goal that very preliminary analysis suggests would be technically and economically feasible.

## **REFORMING THE AIR TRAFFIC CONTROL SYSTEM TO PROMOTE EFFICIENCY AND REDUCE DELAYS**

Deregulation of the U.S. airline industry unleashed competition, bringing air fares within the reach of people of modest means and spurring explosive growth in air travel. Air cargo decontrol fostered the air express sector and the business-altering concept of just-in-time (air) shipments. With good reason, economists view aviation deregulation as one of the most successful public policy reforms of the last 30 years.

Unfortunately, our nation's air traffic control (ATC) system has not kept up. The most visible sign of the problem is flight delays, which have reached historic levels and are likely to get worse. Less visible symptoms include the outdated technology on which the Federal Aviation Administration (FAA) relies and its rising costs of production.

Economists generally agree that the underlying problem is one of faulty incentives. First, air traffic control is a 24/7 high-tech service "business" being run by a traditional government agency (worse yet, by the same agency that regulates ATC). This governance structure leads to inefficient behavior by the service provider, Congress and other stakeholders. Second, the mechanisms used to finance the airways (passenger taxes, principally) and runways (weight-based landing fees) subsidize the operations of small aircraft relative to those of large aircraft. This encourages overuse of regional jets (RJs) and other small planes, which contributes directly to congestion and flight delays. Stated differently, delays are partly a result of the government's perverse system of charging for aviation infrastructure.

Because delays are a drag on the economy, reform of the ATC system should be a government-wide priority. But Congress has staunchly opposed major reform proposals, including the Bush Administration's ongoing effort to replace (some) tax-financing with user fees and the Clinton Administration's proposal to deliver ATC through an independent government corporation.

The goal of this paper is to identify ways to improve the economic incentives facing aircraft operators and the FAA. To set the stage, in section I, I describe the symptoms in more detail. In sections II and III, respectively, I analyze the two underlying problems (governance and financing), and discuss economists' ideal policy fix as well as other, more incremental steps the federal government could take. In section IV, I consider how to facilitate the transition to a next-generation air traffic system that will provide stronger incentives for efficiency.

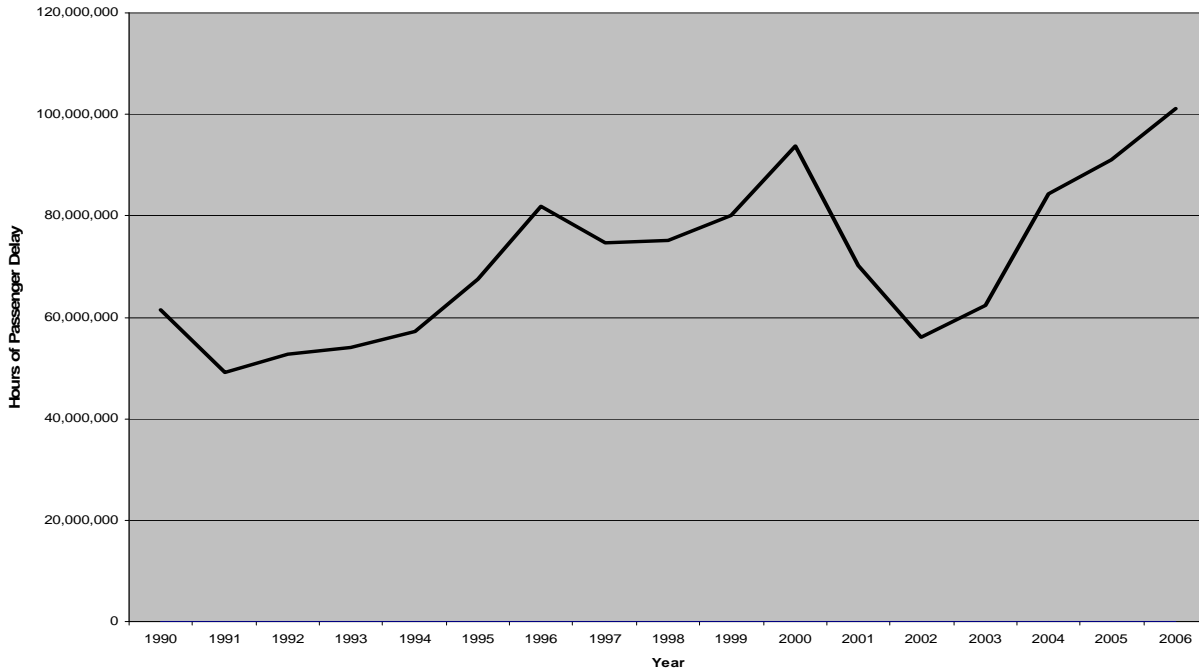
For several reasons, I pay particular attention to the case for replacing the current financing systems with efficient (*i.e.*, marginal cost) pricing. One, economists are unanimous in making that case (there is less agreement on how to fix the governance problem). Two, the FAA has ignored the efficiency case for its user fee proposal; in particular, it has consistently failed to explain what few Members of Congress appreciate—that tax financing directly promotes flight delays. While it may be too late to affect the user fee debate, the same efficiency arguments can help generate support for more incremental options.

# I. SYMPTOMS

## A. Flight Delays

Flight delays are the most visible symptom of the deeper problems that plague our ATC system. During the first five months of 2007, more than 25 percent of domestic flights arrived more than 15 minutes late, and of those flights, 65 percent were more than 30 minutes late.<sup>1</sup> In 2006, passengers lost more than 100 million hours of time due to flight delays (see Figure 1).

**Figure 1**  
**Flight Delays**



Source: ASQP and T100 Domestic Segment

Flight delays are expensive. The Air Transport Association estimates that delays cost airlines about \$7.7 billion in 2006, largely in congestion-related fuel consumption and reduced utilization of crew and aircraft. Passengers ultimately pay that cost. The direct cost to passengers of measured delays is another \$3 billion to \$5 billion a year.<sup>2</sup>

---

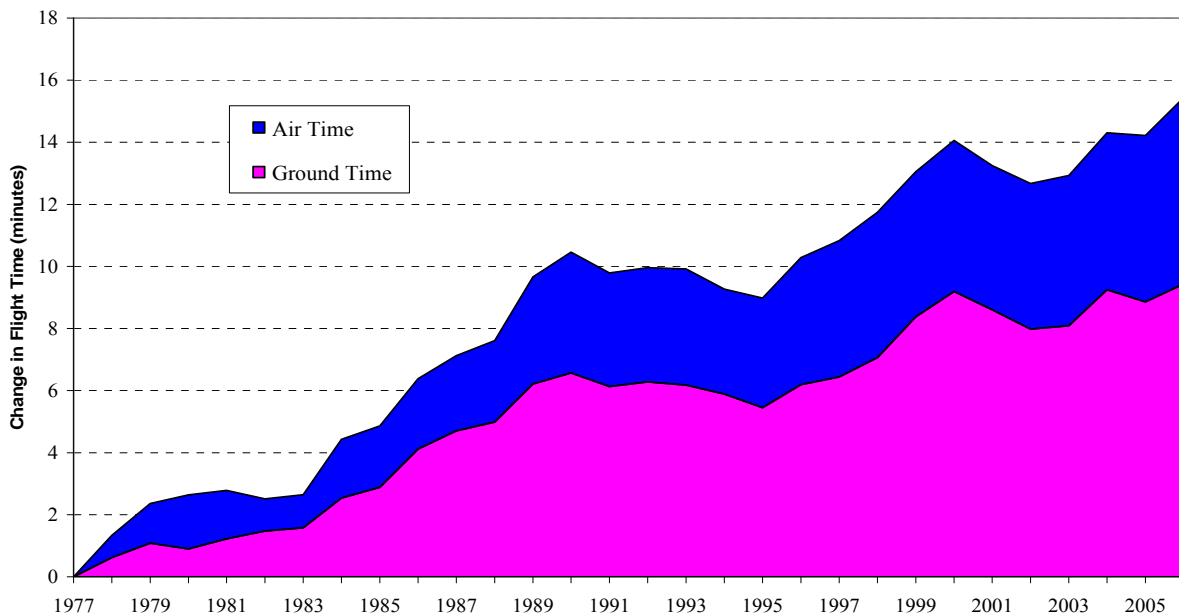
<sup>1</sup> “The Status of the Airport and Airway Trust Fund,” Statement of Peter R. Orszag, Director, Congressional Budget Office, before the U.S. Senate Committee on Finance, July 12, 2007, p. 7.

<sup>2</sup> This range is the product of hours of delay (100 million) times a high and low estimate of the value of passengers’ time (\$50 and \$30 per hour). The 100 million number (Figure 1) is conservative. ATA’s chief economist calculated delays using a larger sample of airports (airports for which data are not available historically) and a slightly different methodology than the one used for Figure 1. By his

These figures significantly understate the costs of congestion. First, statistics on delays exclude flight cancellations and missed connections. Although relatively few flights are cancelled, a cancellation is far more disruptive to a traveler than a delayed flight. Research at George Mason University suggests that cancellations account for 40 percent of actual passenger delays.<sup>3</sup>

Second, airlines have padded their published schedules so that flights arrive “on time” (i.e., within 15 minutes of the flight’s scheduled arrival time) despite routine delays. Figure 2 shows the steady increase in flight travel times, overall, over the last three decades due to air and ground delays. The block times on individual routes are also revealing. For example, according to a recent *Wall Street Journal* column, it now takes 25 minutes longer to fly from New York to Los Angeles than it did 10 years ago, and flights from New York to Washington, DC, which involve only about 35 minutes of actual flying time, are now routinely blocked out at two hours.<sup>4</sup>

**Figure 2**  
**Increase in Flight Travel Times**



Source: Steven A. Morrison and Clifford Winston, “Delayed! U.S. Aviation Infrastructure Policy at a Crossroads,” in *Aviation Infrastructure Performance: A Study of Comparative Political Economy*, edited by Winston and Gines de Rus (Brookings Press, forthcoming).

---

calculation, delays totaled 169 million hours in 2006. Personal communications with John Heimlich, ATA, August 2007.

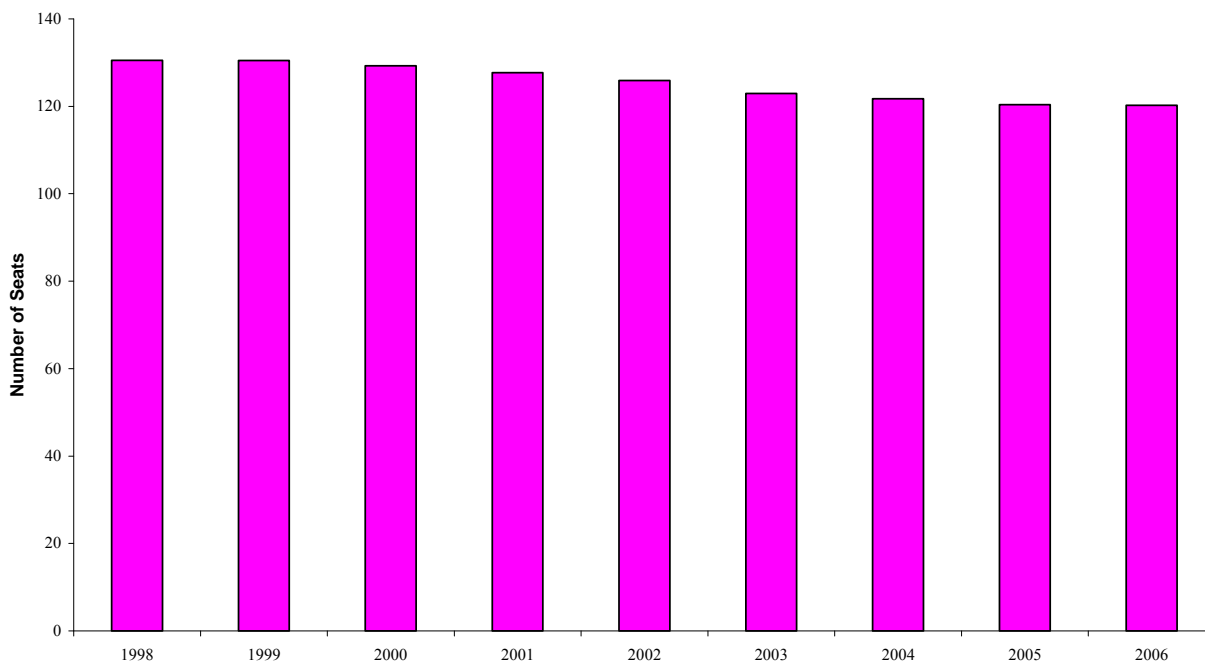
<sup>3</sup> Researchers at George Mason University used 2004 data to look at the 3 million flights that operated on 1044 city pairs between 35 major airports. Of those flights, 20.5 percent were delayed; the delays totaled 52 million hours. By contrast, only 1.78 percent of the flights were cancelled, but those cancellations were responsible for nearly two-thirds as much delay (34 million hours). See slide presentation by George L. Donohue, “Air Transportation: A Tale of Prisoners, Sheep and Autocrats,” January 29, 2007, p. 43. Available at: <http://catsr.ite.gmu.edu/pubs.html>.

<sup>4</sup> Scott McCartney, “The Middle Seat: Why Flights are Getting Longer—Planes are Faster and Navigation Better, but Airlines are Padding Schedules Even More as Congestion Worsens,” *Wall Street Journal*, May 29, 2007.

Taking into account just the impact of cancellations on passenger delays (*i.e.*, ignoring missed connections and schedule padding), the direct cost of delays to passengers in 2006 was more on the order of \$5 billion to \$8 billion.<sup>5</sup>

A proximate cause of this increase in congestion and delays is the decline in average aircraft size. The average domestic passenger aircraft had ten fewer seats in 2006 than in 1998 (see Figure 3). And regional jets now represent more than a third of all commercial flights—up from 9 percent in 2000.

**Figure 3**  
**Average Seats per Aircraft in the U.S. Commercial Domestic Fleet**



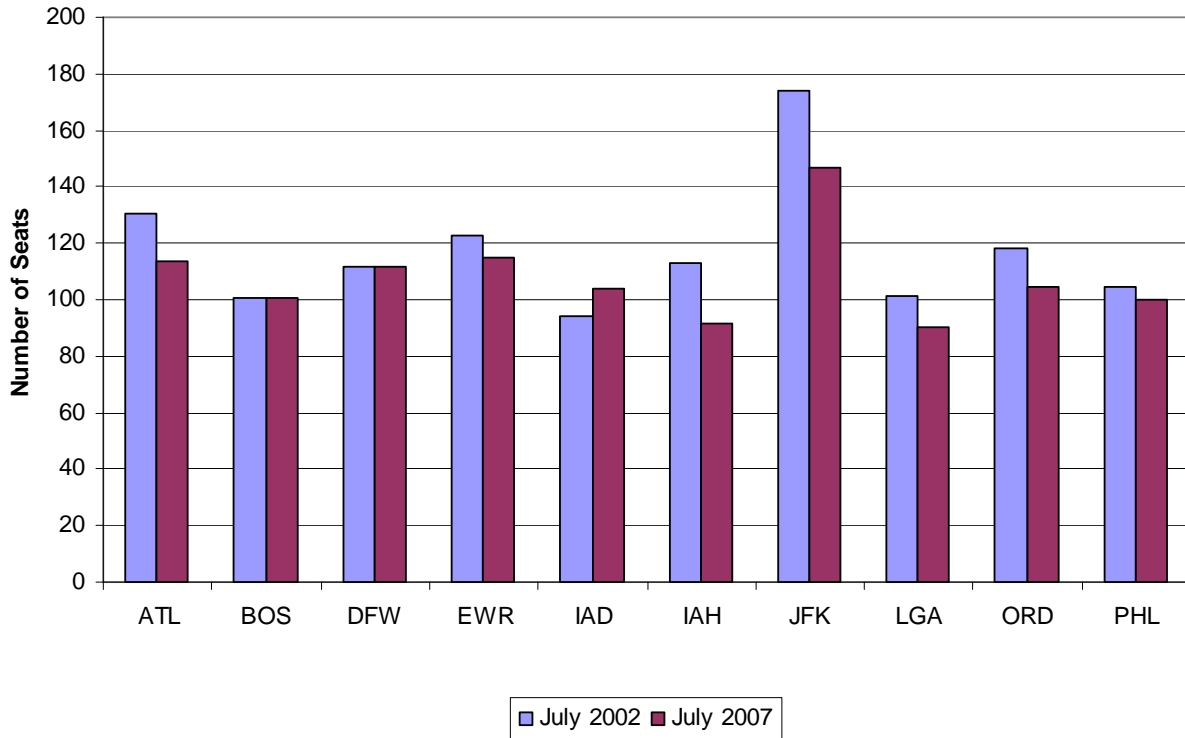
Source: Department of Transportation, Federal Aviation Administration, *FAA Aerospace Forecasts, Fiscal Years 2004-2015* and *FAA Aerospace Forecasts, Fiscal Years 2007-2020*.

This pattern has been especially pronounced at some of the largest, most delay-plagued airports (See Figure 4).

---

<sup>5</sup> The actual figure could be higher still. If measured delays in 2006 totaled 169 million hours (footnote 2), then passenger delays, including cancellations, which account for 40 percent of passenger delays (GMU estimate), totaled 280 million hours. By that measure, using the low and high estimates of the value of passenger time (\$30 and \$50 per hour), the cost of delays to passengers in 2006 was \$8.4 to \$14 billion.

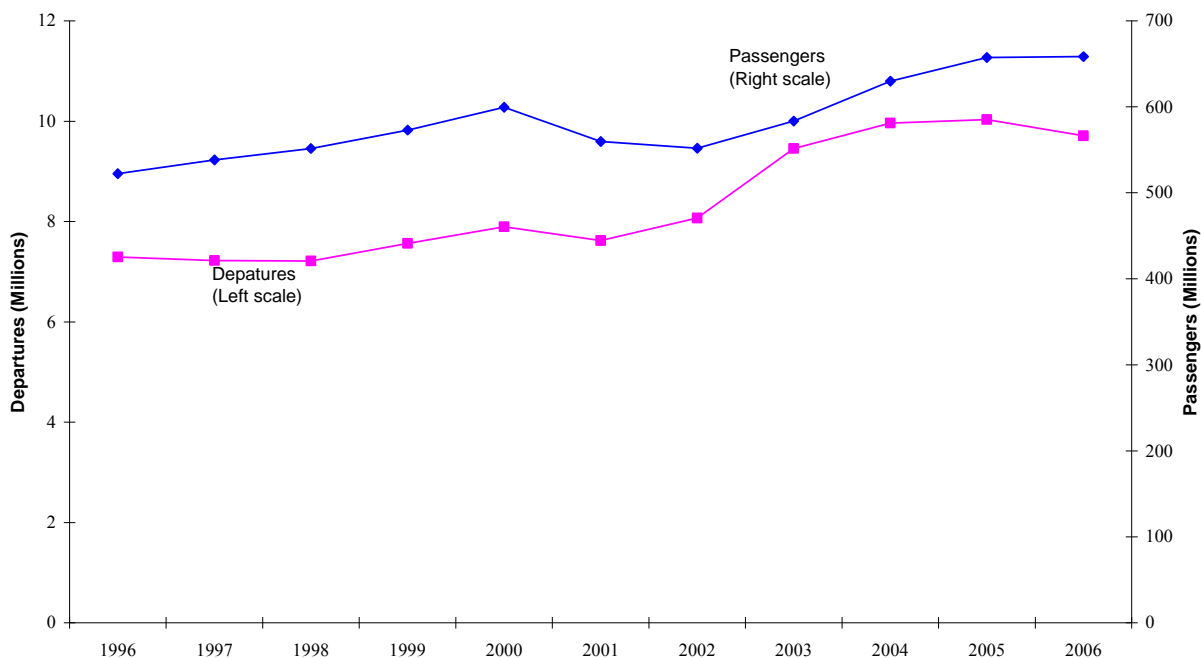
**Figure 4**  
**Average Seat Size by Airport, 2002 vs 2007 (all departures)**



Source: OAG

This trend reflects the fact that commercial airlines are offering more frequent service with smaller aircraft both to attract high-revenue business passengers (“frequency sells”) and to utilize lower-cost pilots. As airlines have down-gauged their fleets, the number of flights has grown faster than the number of passengers: between the first quarters of 2002 and 2007, departures increased by 29 percent compared to a 25 percent increase in passengers (see Figure 5).

**Figure 5**  
**Domestic Scheduled Air Traffic Departures and Passenger Traffic**



Source: Department of Transportation, Bureau of Transportation Statistics, U.S. Air Carrier Traffic Statistics

## **B. Reliance on Antiquated Technology**

A second symptom of the underlying problem with our ATC system is the FAA’s reliance on antiquated technology, including ground-based radar for surveillance and navigation, and analog, voice-only radio communications between controllers and pilots.<sup>6</sup> These World War II-era technologies impose serious limitations on the ATC system. For example, the limited precision of the FAA’s aging radar requires controllers to maintain wide safety buffers between aircraft—a key constraint on available airspace and runway capacity. And planes must zig-zag between terrestrial navigation aids rather than fly the most efficient air routes, consuming fuel and passenger time. Finally, the aging equipment requires a high degree of maintenance.<sup>7</sup>

<sup>6</sup> Well into the 1990s, FAA was the largest U.S. buyer of vacuum tubes, for use in its 30-year-old mainframe computers. “FAA, Inc.,” *Forbes*, August 26, 1996. Vice President Gore waved one of the FAA’s giant vacuum tubes at a 1994 press conference at Washington National Airport, where he unveiled the Clinton Administration’s proposal to corporatize the ATC system.

<sup>7</sup> Although “weather” is the major cause of flight delays, the ATC system is vulnerable to bad weather because it lacks resilience. Part of the problem, according to George Donohue, an engineering professor at GMU and former senior FAA official, is that “the FAA knows very little about weather and route structure disruption.” He points to an incident on July 7, 2004, when the FAA imposed “weather holds” at 10 airports in response to a line of thunderstorms that moved across the eastern United States. This was a “meat-axe” approach, according to Donohue: 80 percent of the delayed flights (2289 of 2872 flights,

Aging equipment is a visible sign of the chronic difficulty the FAA faces in developing and adopting new technology. According to a recent study by economists Clinton Oster and John Strong, the FAA's capital investment programs are characterized by high costs and poor performance.<sup>8</sup>

Most FAA modernization projects have a record of (1) promising more capability than they ultimately deliver, (2) being completed later than promised, and (3) costing far more by the time they are completed than the initial cost estimates.

When the FAA undertook ATC "modernization" in 1981, it estimated the work would cost \$12 billion and take a decade to complete. But as of 2005, the FAA had spent \$43.5 billion on system modernization and it expected to spend an additional \$9.6 billion through 2009.<sup>9</sup> Most of that money has been spent to upgrade and replace ground-based equipment that offers only incremental improvements in capacity and safety. Although the FAA plans to move to a next-generation ATC system, it estimates that the transition will take 20 years.

### C. Flat Productivity and Growing Unit Costs

Despite the FAA's investment in modernization, controller productivity has remained flat over the last 25 years, and ATC production costs have grown significantly. These trends represent a third symptom of the deeper problems that plague the ATC system.

Figure 6 (blue line) shows changes in productivity over time as measured by the number of instrument-flight-rule (IFR) operations per controller. Although there is some year-to-year variation, controllers handled about the same number of instrument operations, on average, in 2006 that they did in 1982. As one basis for comparison, the FAA estimated in the early 1980s that modernization would allow it to increase controller productivity by a factor of more than two.<sup>10</sup>

This stagnant productivity trend is not inevitable: many of the routine tasks that controllers now perform could be performed more efficiently—and more safely—by new hardware and software. For example, a large fraction of all air-to-ground communications involves the handoff of a flight from one sector to another—a task that could and should be automated.

---

accounting for 69,000 minutes of delay) were not even scheduled to traverse the affected area. Telephone interview with Donohue, March 12, 2007; see also Donohue's January 29, 2007 slide presentation, *op cit*.

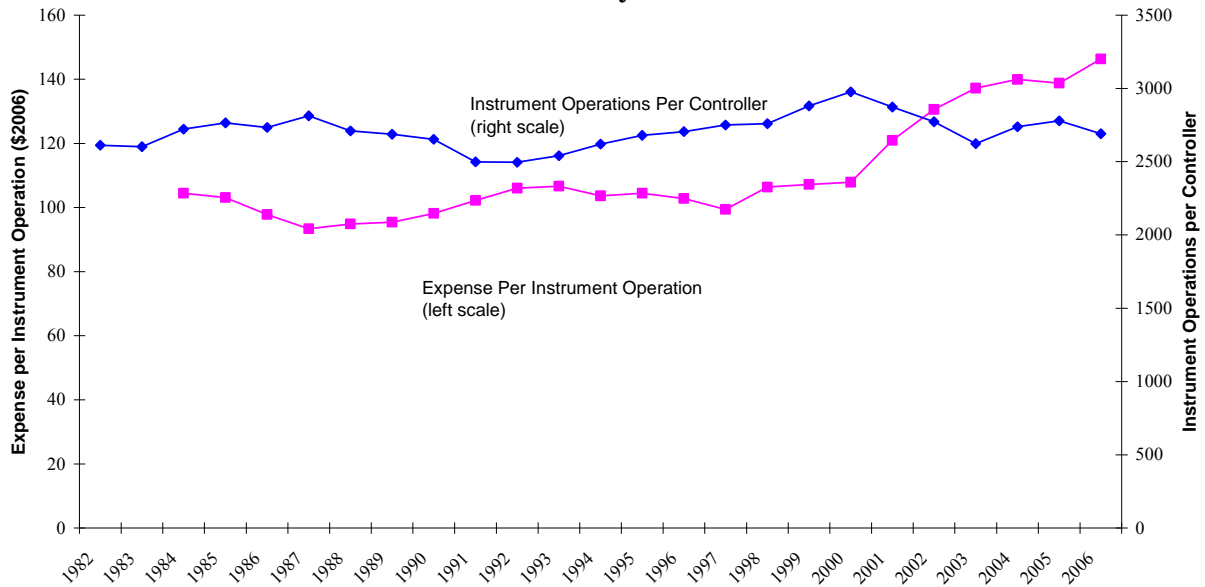
<sup>8</sup> "Reforming the Federal Aviation Administration: Lessons from Canada and the United Kingdom," by Clinton V. Oster, Jr., with the assistance of John S. Strong, IBM Center for the Business of Government, 2006, p. 14.

<sup>9</sup> GAO, "National Airspace System: Experts' Views on Improving the U.S. Air Traffic Control Modernization Program," GAO-05-333SP, April 2005, p. 1.

<sup>10</sup> Congressional Budget Office, "Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan," August, 1983, pp. 14-15 and Table 3.

**Figure 6**

**Controller Productivity and ATC Unit Costs**



Source: Controller work force data are from Department of Transportation, Housing and Urban Development, and Related Agencies Appropriations for 2008, Part 1, FY 2008 Budget Justifications, page 572. Data on number of operations through 1989 are from FAA Air Traffic Activity, Fiscal Year 1994 FAA APO-95-11. Data on number of operations from 1990 onward are from the Air Traffic Activity System (ATADS). Operating expense data are from various editions of the *FAA Administrator's Factbook*.

Figure 6 (red line) also shows the change in the unit cost of ATC production over time as measured by the FAA's cost-per-IFR-operation adjusted for inflation. Although the FAA's unit cost was flat from 1984 to 1997, it has gone up markedly over the last 10 years, for an overall increase of 40 percent. The two major contributors are the 1997 controller contract and the post-9/11 decline in traffic, which was not matched by a decline in ATC capacity/services (or an increase in service quality).

Controllers argue that such a cost increase is "natural," because of the labor intensive nature of ATC delivery. But, as noted above, ATC delivery is not inherently labor intensive. Moreover, the 1997 contract agreement gave controllers large wage increases in exchange for the prospect of major productivity gains—gains that never materialized.

The increase in unit costs following 9/11 may have been harder to avoid. But Canada's corporatized ATC provider, NavCanada, reportedly did reduce capacity in response to the post-9/11 downturn in traffic.

## II. PROBLEM #1: GOVERNANCE

Economists view these symptoms as the predictable result of the flawed governance structure for ATC and the perverse way that ATC is financed. In this section, I examine the governance issue. Section III looks at the financing issue.

### A. The Problem

The air traffic control system operates 24 hours a day, 365 days a year, and an entire industry is dependent on it for its every move. Although the provision of ATC is a monopoly, it is not inherently governmental and, in many respects, it is like a business.

- First, air traffic control activities are purely operational—that is, they involve the delivery of a routine service through the equivalent of a production line. To be sure, air traffic management—like the manufacture of aircraft or the operation of airlines—must be regulated to ensure safety. But experts agree that the *delivery* of air traffic control services is distinct and separable from the *regulation* of air traffic control safety.
- Second, because air traffic control is purely operational, the mission of an air traffic management service provider is clear and its performance is measurable.
- Third, the users of the ATC system (airlines and private aircraft) are identifiable, and most of the benefits and costs of ATC services accrue to those already paying the costs via taxes (passengers, shippers and aircraft owners). By contrast, government agencies typically provide public goods such as clean air and safe streets, for which there may be no correlation between the taxes an individual pays and the services he or she receives.

The governance problem arises because, as a traditional government agency, the FAA is not suited to operating what amounts to a business. David Osborne, whose 1992 book popularized the phrase "reinventing government," sums up this mismatch:

The FAA's problems have been studied repeatedly for at least 15 years; indeed, the FAA has been "commissioned" to death. There is significant consensus about the basic problem: air traffic control is a massive, complex, technology-intensive service business operating within a conventional U.S. government bureaucracy. It is a bit like putting a Ferrari engine into a dump truck body and still expecting it to win races.<sup>11</sup>

Most important, FAA management faces the wrong incentives. Whereas ordinary businesses must respond to customers to survive, the FAA faces more complex incentives. For example, because it relies on appropriated funds, the FAA has historically viewed Congress rather than aircraft operators as its customer. FAA decisions regarding the location and consolidation of

---

<sup>11</sup> David Osborne and Peter Plastrik, *The Reinventor's Fieldbook: Tools for Transforming Your Government*, Jossey Bass, 2000.

facilities, investment, maintenance, and staffing and pay are all subject to congressional micromanagement.<sup>12</sup>

Federal budget rules create their own, perverse incentives. Like other government agencies dealing with infrastructure megaprojects, the FAA faces strong pressures to overestimate the benefits, underestimate the costs and downplay the risks to sell the projects to decision makers.<sup>13</sup> And like other large government monopolies, the FAA faces pressures to maximize output. For example, the FAA has tended to find evidence that its cost structure is characterized by low marginal costs and high fixed costs—evidence that some economists have begun to question. Government monopolies such as the Postal Service tend to overstate their fixed costs, because it sets the stage for price discrimination, which facilitates output expansion.

Finally, because the FAA is subject to pressure from Congress, the executive branch, and elsewhere, it is less accountable for its actions. The 1997 National Civil Aviation Review Commission (known as the Mineta Commission) emphasized that there were “too many cooks” exercising authority on ATC. Oster and Strong reached the same conclusion, emphasizing that such diffused accountability results in inadequate incentives for financial discipline.<sup>14</sup>

## **B. Economists’ Rx: Move ATC Operations out of the FAA**

In an effort to address the institutional mismatch—and pursuant to an executive order issued by President Clinton—the FAA in 2004 restructured its air traffic operation as a separate, performance-based unit within the agency.<sup>15</sup> The Air Traffic Organization (ATO) made major strides toward becoming more business-like under the very able leadership of Russell (Russ) Chew. However, severe institutional constraints remain, and congressional micromanagement, which the ATO structure was never designed to address, remains pervasive.

For just this reason, most economists believe that the ATO’s function should be entrusted to an organization outside of the traditional government bureaucracy, with continued oversight by safety regulators. An autonomous organization could focus more on satisfying its customers than a traditional government department is able to do. In addition, it could more easily access

---

<sup>12</sup> FAA efforts to consolidate facilities—a major source of potential savings—have repeatedly been thwarted by Members opposed to the loss of jobs in their district. Decisions regarding the location of towers and TRACONS are likewise subject to congressional pressure. Morrison and Winston conclude that, if the FAA were to reallocate its expenditures at towers and TRACONS toward airports that experienced the most costly delays, savings to travelers and airlines would exceed \$1 billion a year. Steven A. Morrison and Clifford Winston, “Delayed! U.S. Aviation Infrastructure Policy at a Crossroads,” in *Aviation Infrastructure Performance: A Study of Comparative Political Economy*, edited by Winston and Gines de Rus (Brookings Press, forthcoming).

<sup>13</sup> Statement of Mark M. Hansen, Professor of Civil and Environmental Engineering, Institute of Transportation Studies, University of California, Berkeley, before the Senate Committee on Finance, July 12, 2007.

<sup>14</sup> Oster and Strong, *op cit.*, p. 14.

<sup>15</sup> Executive Order 13180—Air Traffic Performance-Based Organization, December 7, 2000.

those inputs to ATC delivery that can be provided competitively, and would have the option of accessing the capital markets directly without the constraints of government borrowing limits.

A further rationale for moving air traffic operations out of the FAA is to enhance safety. Currently, the FAA both regulates and operates the ATC system—the equivalent of having the Food and Drug Administration manufacture drugs as well as regulate the manufacturing process. Making the ATC service provider independent from government safety regulators would bring transparency to the regulatory process and eliminate any potential conflict of interest.<sup>16</sup>

However, economists do not agree on the best governance structure for ATC; options include a government corporation, a user-owned cooperative, and a private, for-profit corporation. In particular, some economists view privatization as too risky because of the lack of competition.<sup>17</sup> In contrast to a privatized provider, a user-owned cooperative has an incentive to protect users' interests, although it might possibly be tempted to restrict supply, thereby harming consumers.

In practice, NavCanada, which is effectively a user-owned cooperative, is widely viewed as the best existing model. Since it was spun off of Transport Canada in 1996, NavCanada has significantly lowered its fees (Canada moved from a ticket tax to a user fee when NavCanada was created). It has also reversed its predecessor's poor track record on modernization—a record remarkably parallel to the FAA's but on a smaller scale—and is now selling its technology to other ATC providers.

By contrast (and consistent with economists' theoretical concern), the International Air Transport Association has complained that some of Europe's commercialized ATC providers are guilty of monopoly pricing. Nevertheless, GAO's review of five commercialized providers (Australia, Canada, Germany, New Zealand and the United Kingdom) was generally positive:

Data from all five indicate that safety has not eroded...All five ANSPs [air navigation service providers] have taken steps such as consolidating facilities, to control their operating costs. Finally, all five ANSPs have invested in new technologies that the ANSPs say have lowered their costs by increasing controllers' productivity and produced operating efficiencies, such as fewer or shorter delays. Such measures have generally resulted in lower fees for major carriers, but some smaller, formerly

---

<sup>16</sup> Economists Oster and Strong provide a succinct analysis of this issue: "With air traffic control, FAA is both the operator of the system and the regulator of the operations. Thus, FAA makes the capacity versus safety trade-offs internally. With the formation of the ATO, there is greater separation of regulations from operations than previously. However, both the regulatory and operations offices are still part of FAA. FAA, in effect, self-regulates air traffic control rather than having arm's-length regulation, as it has with airline operations, aircraft design and manufacture, and virtually every other aspect of aviation. Self-regulation of air traffic control creates long-recognized potential conflicts of interest when there are decisions to be made about trade-offs between safety and capacity." "Reforming the Federal Aviation Administration: Lessons from Canada and the United Kingdom," *op cit.*, p. 16.

<sup>17</sup> Joseph Stiglitz, "Airports Debacle Worsened by Greed and Neglect," *Financial Times*, August 21, 2006.

subsidized users now pay new or higher fees and are concerned about future costs and service.<sup>18</sup>

### C. Near Term Steps to Improve Governance

#### *Reestablish the Oversight Subcommittee to the MAC*

The 2000 FAA reauthorization bill created a five-member Subcommittee to the FAA Management Advisory Committee MAC that was designed to serve as a “corporate board” to oversee what became the ATO. The Subcommittee had real authority: for example, it could veto procurement decisions worth more than a specified amount. Although FAA and DOT officials made it impossible for the Subcommittee to do its job at the time (2001), the concept was a good one and deserves reexamination.<sup>19</sup>

#### *Increase User Input*

Users have only limited input into FAA decisions on investments, technology deployment, and other critical issues, and the FAA’s lack of accountability is a major source of the problems with our ATC system. The advisory board proposed in the Administration’s reauthorization bill is an excellent step. Short of adopting a NavCanada governance structure, there are some other steps that the federal government could take to increase stakeholder input:

*Give Users a Seat on JRC:* The FAA’s Joint Resources Council (JRC) has the authority to approve major ATO investments. Users should have representation on it.

*Require Disclosure on F&E Budget:* The FAA’s Facilities and Equipment division procures outside technical support for operations and modernization. Increased transparency would allow users to examine the number and size of contracts and consider whether any of them create conflicts. The FAA should disclose the description and value of each contract over (say) \$50 million per year, as well as a description of the goods and services received, and the type of procurement (competitive, sole source, limited competition, or follow-on).

*Require Disclosure and Consultation on ATO Budget:* Similarly, disclosure on ATO spending would allow users to see what it costs to provide specific services, and to compare the relative efficiency of individual facilities. The FAA should provide facility reports from the Cost

---

<sup>18</sup> GAO, “Air Traffic Control: Preliminary Observations on Commercialized Air Navigation Service Providers,” Statement of Gerald L. Dillingham, Director, Physical Infrastructure Issues, before the Subcommittee on Aviation, House Committee on Transportation and Infrastructure, April 20, 2005.

<sup>19</sup> In December 2000, President Clinton named five distinguished individuals to this Subcommittee, including then-CSX CEO John Snow. The Subcommittee selected Snow as its chairman, and he assumed his duties with a great deal of enthusiasm (*e.g.*, he recruited a highly regarded economist, Darius Gaskins, to develop metrics for the ATC system—well before the FAA took a similar step—and he met personally with NavCanada CEO John Crichton). Unfortunately, the FAA kept the Subcommittee on a “short leash,” and in late 2001, the then-Deputy Secretary of DOT refused to give the Subcommittee the budget it had requested—and which the FAA Administrator had approved. Snow reportedly gave up in frustration.

Accounting System within 90 days of the close of the fiscal year. Required disclosure should also include data on key cost drivers.<sup>20</sup> Users should be allowed to file public comments during this consultation, to which the FAA would have to reply.

### ***Create an Independent Benchmarking Capability***

The European Commission established a Eurocontrol Performance Review Commission (PRC), which is external to Europe's national ATC providers. The PRC has done a series of detailed benchmarking studies comparing individual European national providers with one another and with their U.S. counterpart on the basis of production costs, productivity levels and other measures. These studies have helped to stimulate a marked downturn in unit costs in just a few years, according to one U.S. expert.<sup>21</sup> A similar organization is needed here. A key task would be to analyze the differences in costs and productivity among ATO facilities.

---

<sup>20</sup> Cost data could include the number of ATO staff by grade, position and function; the hours of operation for each facility; and detailed activity data for each facility (*i.e.*, how is output measured, how many services are produced, and who uses the services). Also relevant is the data on overhead per facility.

<sup>21</sup> Statement of Mark M. Hansen, *op. cit.*

### III. PROBLEM #2: FINANCING

The second structural problem with ATC is the financing mechanism. Under tax-financing, aircraft operators do not face the real cost they impose on the system, which leads them to use it inefficiently. And the FAA gets none of the customer feedback that prices provide.

#### A. The Problem: Tax Financing of ATC

The FAA's ATC operation is funded largely by federal excise taxes—principally, an *ad valorem* “ticket tax” and a flat charge per flight segment, both paid by airline passengers. Cargo carriers pay the equivalent of a ticket tax—an *ad valorem* tax on the charge to shippers. And most business aviation and general aviation users pay a fuel tax (air taxis and fractional jets pay a ticket tax). Economists have long criticized tax-based financing of ATC for creating market distortions, leading to flight delays and other economic inefficiencies.

Tax financing encourages overuse of scarce ATC capacity in part because commercial airlines pay for that capacity only indirectly, through passenger taxes, rather than directly. Moreover, a small aircraft contributes less in taxes than a large one, even though it costs the ATC system about the same amount to serve them. For example, a 140-seat Airbus A320 flying from Denver to Phoenix contributes \$1498 in taxes whereas a 50-seat regional jet pays only \$502.<sup>22</sup>

Consider the incentives to an airline. By substituting two RJs for one large jet, the airline can offer more frequent flights—a major draw for high-yield business passengers. Although that substitution doubles the FAA's workload, the airline and its passengers pay only a fraction more in total ATC taxes. That partly explains why use of RJs has more than tripled since 2000. Airlines are providing what customers want—more frequency. But because of our perverse way of charging for ATC, the airlines reap the benefits without paying the cost.

Most important, the current funding system ignores the congestion costs that additional flights impose on other travelers—costs that vary widely depending on when the flights operate—whether at busy or slack times—and what airports they use. Because users are not charged the full cost of scarce air traffic control capacity—and because airlines pay only indirectly—they tend to use it inefficiently.

Although airlines in the aggregate cover their costs to the ATC system, business jets, which pay a fuel tax, contribute far less than the burden they impose—creating an additional subsidy to small aircraft. A 6-passenger Gulfstream 450 corporate jet flying from Denver to Phoenix contributes only \$133 in taxes even though it uses the same airspace—and requires the same attention from controllers—as the commercial A320 paying \$1498. And while business jets typically avoid the crowded large-hub airports, the rapid expansion of traffic to neighboring reliever airports—such as Teterboro, near the Newark airport—has added to hub congestion.<sup>23</sup>

---

<sup>22</sup> These figures and the ones below are from the Air Transport Association.

<sup>23</sup> Very Light Jets represent the next phase in the downsizing of U.S. aircraft. Microjets are in some respects the aviation equivalent of sports utility vehicles; just as SUVs depend on cheap gas for their popularity, microjets are arguably in part a reflection of under-priced ATC services.

Tax-based financing encourages inefficiency on the FAA's part as well. Unlike a commercial firm that charges customers for its products, the FAA cannot compare its costs and revenues to learn how customers value its various services, where it needs to reduce costs, which services to develop or improve, or where to invest new capital. Among other things, the FAA has no incentive to provide value-added services because it cannot charge users for them. Nor can it provide economic incentives for users to adopt on-board equipment, even when that would lower the FAA's operating costs or reduce needed investment in ground-based technology.

Finally, tax financing impedes investment. As structured, trust fund taxes do not provide signals to the FAA as to how much additional capacity is needed and where. Moreover, under current budget rules, capital expenditures by the tax-funded ATO are expensed against current receipts—*i.e.*, they are on-budget. As a result, current users pay for capital investments that will benefit future users, a source of inefficiency. And given the tight constraints that the federal budget has faced, R&D and long-term investments may get shortchanged.

### **B. A Parallel Problem: Weight-Based Landing Fees**

The landing fees imposed by local airport authorities have the same perverse effect as ATC taxes. In keeping with airport authorities' understanding of ambiguous and outdated federal policy, landing fees are set low, to promote aviation, and based solely on aircraft weight. Thus a Boeing 747 with 416 seats pays several thousand dollars to land at O'Hare while a Boeing 737 with 128 seats pays a few hundred dollars. RJs and corporate jets pay far less.<sup>24</sup>

In reality, aircraft weight is a poor measure of wear-and-tear costs (what matters is how the weight is distributed). But, more important, weight-based fees ignore the far larger delay costs that users impose on others at a congested airport. These costs are roughly constant for all aircraft because what is key is the opportunity cost, and a small plane uses up a landing slot that could have gone to a large plane.<sup>25</sup>

Because time-uniform, weight-based landing fees ignore delay costs, they provide little incentive for users to shift flight activity to off-peak hours or less congested airports, or to substitute fewer flights in larger planes for multiple flights in smaller planes.

### **C. Economists' Rx: Marginal Cost Pricing**

Adoption of efficient pricing would be the single most effective step the federal government could take to reduce delays and improve the air traffic control system.<sup>26</sup> A shift from tax-

---

<sup>24</sup> Dorothy Robyn, "Ending Runway Gridlock," *Blueprint*, September 2001; available at: <http://www.dlc.org/print.cfm?contentid=3764>.

<sup>25</sup> Michael E. Levine, "Landing Fees and the Airport Congestion Problem," *Journal of Law and Economics*, Vol. 12, April 1969, pp. 79-108.

<sup>26</sup> Transportation Research Board, National Research Council, *Entry and Competition in the U.S. Airline Industry: Issues and Opportunities*, National Academy Press, 1999. Although the discussion below

financing to a well-designed system of prices could have far-reaching beneficial effects over time. Such prices would provide incentives for:

- More economically efficient use of the system by aircraft operators (allocative efficiency)
- More efficient provision of ATC by the FAA (productive efficiency)
- Investment in innovation and new technologies (investment efficiency)

### *Allocative Efficiency*

In the short run, when supply is fixed, prices would provide an incentive for more efficient use of scarce air traffic control capacity: prices ensure that users value the services they use sufficiently to pay their costs. This would reduce system costs, including delay costs, by discouraging inefficient patterns of use.

Ideally, fees would vary by time of day to reflect the delay costs that an additional flight imposes on other users. However, some of the congestion we experience now is attributable to the perverse financing mechanism itself, which subsidizes small aircraft operations. Thus, there is an argument for moving initially to a flat, per-flight charge with no time-variant congestion component. Such a charge should lead to some reduction in congestion by eliminating the current bias in favor of small aircraft.<sup>27</sup>

### *Productive Efficiency*

Prices would also encourage more efficient provision of ATC services by the FAA. The FAA would get the basic information that producers get from prices: do users value the services enough to pay their cost? By comparing its costs and revenues, the FAA could better decide which services to expand or contract. If prices varied by location, FAA would get more meaningful information on individual facilities—information that would facilitate consolidation.

In addition, the FAA could offer, and customers could purchase, the services that best met their needs, as opposed to the current, one-size-fits-all. Such value-added services might include:

- One airline gets priority in the system in exchange for paying higher ATC charges

---

focuses on the benefits of efficient pricing of ATC (*i.e.*, airways), the same arguments apply to efficient pricing of airport runways.

<sup>27</sup> Just how much reduction in congestion a flat charge would yield is a key question that economists need to investigate empirically. Anecdotal evidence suggests that U.S. airlines are highly price sensitive. For example, airlines use a commercial software program that tells them whether it would be cost-effective to fly through Canadian airspace, based on the combination of gas savings and NavCanada fees. See Susan Carey, “How Flight-Planning Software Helps Airlines Balance Fuel, Distance, Wind, ‘Overfly’ Fees,” *Wall Street Journal* (March 6, 2007). Stylized examples also show that a shift to a movement-based charge would change the relative profitability of operating a Boeing 737 versus a 70-seat RJ. See Daniel P. Kaplan, LECCG, “Introducing Sensibility to ATC Funding,” PPT Presentation, April 30, 2007.

- A group of airlines pool resources to pay FAA for extra service during peak hours
- A global alliance leases an “exclusive” route on the North Atlantic

Still other customers may prefer less service in exchange for lower fees—analogue to “interruptible” electricity service.

It is no coincidence that Canada shifted from a ticket tax to direct user financing at the same time NavCanada was created. Both changes were designed to give system users a more direct link to the service provider, as captured by their oft-cited expression, “User pay, user say.”

A panel of experts on the National Airspace System expressed a similar view, stressing the importance of the direct user-ATO link that user fee financing would provide:

Replacing airline ticket taxes with a user fee and allowing the ATO, rather than Congress, to manage the collected fees is a step that many panelists considered essential for the ATO’s success....A user fee system would link air traffic services directly with demand, panelists pointed out....Not having a direct financial link between the ATO and the users can create inefficiencies, panelists said: The users lack incentives to monitor the ATO’s spending and may not insist on cost control, while the ATO lacks incentives to consult the users and may invest in technologies that the users do not want. A user fee makes the ties between the funding source and the users “much more transparent,” according to one panelist, and helps preclude spending for “gold-plated things that don’t affect the true performance of the system and drive the costs up completely unnecessarily.” Without a direct connection to the users and their mission, another panelist said, “evolution takes very unintended and very undesirable paths over long periods of time.” As long as the customers are not directly paying the bills and providing the resources, still another panelist maintained, “it’s going to be very hard to bring about real change” and make the ATO “a customer-driven, customer-servicing organization. The ones who pay the bills are the ones you respond to and serve,” he concluded.<sup>28</sup>

### ***Investment Efficiency***

In the long run, a system of prices will encourage innovation and efficient investment. With the FAA moving to a next-generation system in the coming years, the most important benefit of prices may be to guide investment and facilitate technology adoption.

Unfortunately, the FAA has advocated user fees principally as a way to pay for a next-generation ATC system. Others have gone further, saying they can’t agree to user fees without a more detailed blueprint of NextGen. But this view has it backwards. NextGen is an economic undertaking; the technology issues are secondary to—and should be driven by—economic considerations. Prices are essential for allowing the FAA and users to decide what’s economically efficient—*i.e.*, what users are willing to pay for.

---

<sup>28</sup> GAO, “National Airspace System: Experts’ Views on Improving the U.S. Air Traffic Control Modernization Program,” *op cit.*, pp. 29-30.

In addition to signaling what users really want, prices can facilitate technology development and innovation. Individual FAA investments often benefit one subset of users more than others. FAA makes investment decisions based on an overall cost-benefit analysis; but opposition from some users may impede projects that would be efficient overall. A pricing system could facilitate “deals” between different user groups, resulting in more efficient investment decisions

Prices could also speed the adoption of new equipment on-board the aircraft. Many of the technical capabilities needed for NextGen already exist. But early adopters of these capabilities often take on additional risk and cost, and they receive no benefits until there is a critical mass of users. Thus, the incentive is to let others equip first.<sup>29</sup>

Equipage has been a major stumbling block in FAA modernization for just this reason. In theory, the FAA could mandate equipage. In practice, this rarely happens, which is not necessarily a bad thing. By offering first-adopters a discount on fees that reflected savings to the system (or by charging late adopters a higher fee, reflecting added costs to the system), the FAA could break this impasse.<sup>30</sup>

In addition, cost-based pricing could facilitate localized investment decisions. Individual carriers might find it economic to finance capacity-expanding and/or delay-reducing investments at specific airports where their operations are concentrated.

Granted, prices are not the only way to achieve market outcomes. Instead of offering a discount on fees, the ATC provider could give equipped users preferable treatment or preferred airspace.<sup>31</sup> But a pricing system offers greater flexibility.

Finally, a system of user fees—together with the appropriate changes in governance—would allow the FAA to issue bonds to finance major projects. This would address a key source of inefficiency: the tendency to postpone long-term investments during periods of government budget stringency.

---

<sup>29</sup> Aerospace engineers refer to this as the “first third” problem, because a third of all aircraft typically must equip before any individual user benefits. See Michael S. Lewis, Boeing, “A Non-Traditional Approach to Mitigate the Aircraft Equipage Roadblock to Air Traffic Modernization: Solving the ‘First 1/3’ Problem,” Unpublished draft prepared when Lewis was a NASA detailee to the Aerospace Commission.

<sup>30</sup> NavCanada has already done this: aircraft operators equipped with datalink on oceanic routes are charged lower fees, in keeping with the savings to NavCanada.

<sup>31</sup> For example, NavCanada is installing ADS-B ground infrastructure in Hudson Bay. Aircraft that are not equipped will have to fly in lower airspace; the cost of increased fuel consumption will be a strong incentive for those aircraft to adopt ADS-B. The FAA used a similar approach when it phased in RVSM (reduced vertical separation minimum).

## D. Airport Congestion Pricing

Flight delays are a solvable problem. As discussed above, delays are a direct result of the perverse way that airways and runways are priced. If the current approach to financing aviation infrastructure were replaced with a sensible one, passengers would quickly see improvement. Stated differently, even without additional runways, the government could allocate existing capacity more efficiently.

The Bush Administration's recent FAA reauthorization bill represents one approach: it would replace (some) tax financing with user fees and give the FAA the authority to impose congestion charges in complex airspace. Another approach is to let the airport "price the scarcity." Toward that end, the Administration's bill would create a pilot program for testing market allocation of runway capacity at up to 15 congested airports. While the controversy over user fees has dominated the debate, the proposed pilot program has received relatively little attention.

The FAA has devoted considerable effort over the last few years to studying market-based approaches to congestion management.<sup>32</sup> Although a detailed analysis of this issue is beyond the scope of this paper, it is worth noting that there are two general approaches to congestion pricing: slot auctions and administratively-set prices. In theory, the two approaches should arrive at the same, efficient allocation of scarce capacity, but each has strengths and weaknesses. Administrative pricing is easier to implement but provides less certainty about the resulting level of congestion. An auction is more difficult to design and operate but provides greater certainty about congestion levels.<sup>33</sup>

The system in place at LaGuardia and O'Hare airports is a variant on auctions: the FAA awarded operators a fixed number of slots, which can be bought and sold in a secondary market. However, this system is fundamentally flawed. Most important, slots are subject to a use-or-lose policy, which reduces the incentive for a slot-holder to use it efficiently.<sup>34</sup> In addition, the secondary market does not produce an efficient allocation of slots.<sup>35</sup> LaGuardia's slot system faces additional challenges, including a perimeter rule, exemptions for small community service, and a slot cap that may be too high even during good weather.

---

<sup>32</sup> See, for example, Michael Ball, George L. Donohue and Karla Hoffman, "Auctions for the Safe, Efficient and Equitable Allocation of Airspace System Resources," in *Combinatorial Auctions*, by Peter Crampton, Yoav Shoham and Richard Steinberg (editors), MIT Press, 2006.

<sup>33</sup> Edward Murphy and John D. Worth, "Some Regulatory and Institutional Barriers to Congestion Pricing at Airports," Office of the Assistant Secretary for Economic Policy, U.S. Department of the Treasury, Research Paper No. 2001-01, May 2001.

<sup>34</sup> The use-or-lose policy limits the exclusivity of the property right represented by the slot, which is a necessary condition for achieving an efficient outcome. Consider an airline that has two adjacent slots each with an RJ scheduled. If the airline had an exclusive right to those two slots, it might decide to schedule a large aircraft for one slot and leave the other slot empty, thereby increasing the odds that it would be able to operate the large aircraft when airport capacity was reduced. But under current policy, such an efficient use of resources is not feasible, because a carrier will lose any slot it leaves empty.

<sup>35</sup> Comments of the United States Department of Justice before the Federal Aviation Administration, Department of Transportation, Congestion and Delay Reduction at Chicago O'Hare International Airport, Docket No. FAA-2005-20704, May 25, 2005.

Although airports have expressed interest in using congestion pricing to manage demand, they face two impediments. One impediment is resistance from some stakeholders, particularly airlines, which now collect the rents that scarcity yields in the form of higher fares. Overcoming this opposition is a genuine challenge, but it may be feasible in the current climate.<sup>36</sup> Key to success is some kind of revenue-sharing or other arrangement that leaves airlines no worse off.<sup>37</sup>

A second impediment is DOT's Rates and Charges Policy, which airports perceive as a barrier to market-oriented solutions. An examination of that policy is beyond the scope of this paper, but it seems to be a self-inflicted wound that requires immediate and intensive treatment. Pogo's oft-cited observation—"We have met the enemy, and the enemy is us."—seems apt here.

DOT might make funds available for airports or other local authorities to implement individual approaches to congestion pricing—the aviation equivalent of what DOT has done for surface transportation. Such a step would send a clear message that the Department is receptive to the use of market mechanisms to reduce airport congestion. It would also spur activity at the local level. Relatively small amounts of money can catalyze a great deal of local activity.

At some airports (*e.g.*, New York), it may make sense for the federal government—rather than the airport authority—to impose congestion pricing. This will be the focus of a great deal of analysis and discussion in the coming months. But it's worth noting that the FCC's auction expert recently cautioned DOT against being too incremental: he recommended that the Department's first market-based intervention to reduce congestion should be sufficiently bold that passengers will notice the improvement.<sup>38</sup>

What FAA should not do is to allocate capacity administratively, as it did when it got United and American Airlines to agree to reduce their demand at O'Hare. Nor should the FAA encourage airlines to solve the delay problem on their own. Seven years ago, the airlines' sought antitrust immunity in order to coordinate to reduce delays. That was a bad idea then and it is still a bad idea.<sup>39</sup>

---

<sup>36</sup> Public officials blame the airlines for flight delays (unfairly so in my view) and so may be less sympathetic to airline objections to congestion pricing. Moreover, reporters, public officials and others "get" congestion pricing—presumably because they see it used in so many parts of the economy. (By contrast, they do not as easily grasp why replacing passenger taxes with user fees will reduce delays.)

<sup>37</sup> See, for example, "A Voucher Proposal to Redevelop Encumbered Airport Slots," Presentation to NEXTOR Workshop by Evan Kwerel, Office of Strategic Planning and Policy Analysis, Federal Communications Commission, June 22, 2004.

<sup>38</sup> Evan Kwerel, Meeting with Senior DOT Officials, September 12, 2007. Kwerel is the staff economist most responsible for educating the FCC on the virtues of auctions. He told DOT officials that the FCC put a great deal of thought into selecting the spectrum for the first auction, to ensure that it would get positive reviews. He also cautioned against imposing a political agenda on a market process.

<sup>39</sup> Dorothy Robyn, "Congress' Plan to Reduce Flight Delays is not Airworthy," *Policy Matters*, AEI-Brookings Joint Center for Regulatory Studies, May 2001; "Flight Delay Repair That Won't Fly," *Washington Times*, August 2, 2001.

## E. Policies to Improve Allocation of GDP “Slots”

FAA ground delay programs (GDPs) offer a particularly good opportunity to improve on the current allocation of scarce capacity. Below, I describe the current approach and then look at three ways it might be improved.

### *How it Works Now*

When the system is congested, the FAA slows down the flow of arrivals into an affected airport by imposing a GDP at the appropriate departure points. Typically, a GDP occurs when inclement weather forces the adoption of IFR-based separation rules in a terminal area, but a closed runway or a large volume of en route traffic can also trigger a GDP. A GDP usually lasts for several hours.

When the FAA imposes a GDP, it uses an automated program—the Enhanced Traffic Management System (ETMS)—to forecast traffic patterns and volume. ETMS gives each affected aircraft an expected departure clearance time (EDCT), and these EDCTs can change as conditions improve or demand decreases. Within the affected geographic areas,<sup>40</sup> EDCTs—also referred to as “slots”—are initially assigned based on the flight plan’s schedule (rationing by schedule, or RBS—another name for first-come, first-served). However, the FAA allows airline users to rearrange their assigned slots on a limited basis.

First, at any time during a GDP, an individual airline can rearrange its own slot assignments (known as “substitution”) to optimize its operations. This is one of the most important features of the FAA’s Collaborative Decision Making (CDM) program, which was instituted in the 1990s partly in an effort to decentralize ATC decisions that have an economic impact on airlines.

Second, the Slot Credit Substitution (SCS) program allows for the anonymous transfer of slots *between* airlines on a limited basis—namely, a one-to-one slot bartering arrangement driven by a situation in which a carrier cannot use its departure slot. SCS was instituted in 2003 as part of CDM to help airlines with a relatively small presence at an affected airport. Although SCS has been helpful in reducing delays, it fills a very narrow niche.<sup>41</sup> Among other things, a carrier can trade “down” but not “up”—*i.e.*, it can give up its departure slot only for a later time slot. Moreover, carriers cannot trade directly (the FAA must mediate) nor exchange money.

---

<sup>40</sup> The FAA typically imposes ground holds first on flights within the same ATC center as the affected airport. By delaying the shorter flights first, the FAA can respond to transient conditions such as weather. If the condition persists, the FAA grounds flights in adjacent centers next. The longest flights are the last ones to be grounded, in part because they are generally the most valuable to the airlines.

<sup>41</sup> According to a 2004 MBA thesis, an airline initiates SCS under three different circumstances: a) when an airline cancels a flight but is not able to move any of its other flights to the vacated slot because of a gap in its schedule; b) when a flight that cannot make its EDCT and the airline has no other flights that can utilize that slot; and c) when an airline wants to protect a critical flight that will otherwise be canceled because it has no other slots to assign to the flight. Ravi Sankararaman, “Impact Assessment of Dynamic Slot Exchange in Air Traffic Management,” Thesis Prepared for a Master of Science in Business Administration, University of Maryland (2004). See also Ball, Donohue and Hoffman, *op cit*.

### *Spot Market*

As a natural extension of SCS, the FAA could establish a spot market in the slots assigned by ETMS following a ground delay. Carriers could buy and sell one or more slots for monetary compensation—presumably based on the marginal value to them of a reduction in the delay facing their respective flights. The spot market could operate *ex ante* or in real time, but, as with SCS, it should be blind so as to reduce the potential for anticompetitive behavior.<sup>42</sup>

A spot market in ETMS departure slots could facilitate many types of transactions that the current SCS program cannot address. For example, if Carrier A had many more passengers on its flight than Carrier B, Carrier B might be willing to give up its earlier slot in exchange for Carrier A's later slot and several hundred dollars in compensation. As another example, Carrier C might be willing to pay for Carrier D's earlier slot so as to avoid having its crew "time out."<sup>43</sup>

More generally, when the air traffic system is even moderately disrupted, carriers need to adjust their flight schedules dynamically. Thus, a spot market in departures can provide significant benefits by ensuring that the flights most highly valued by the operator receive priority.

Among other advantages, a spot market will favor flights on larger aircraft, leading to reduced passenger delays. Predictably, carriers use the SCS program to preserve their flights on larger aircraft at the expense of their flights on RJs and other small aircraft. A spot market will underscore that tendency—a useful offset to the perverse incentive that ATC financing currently provides. Although this will not reduce *flight* delays (delays per plane) it will reduce the number of hours that *passengers* are delayed, which is what matters.

Over time, the FAA may want to allow a spot market to operate daily, not just when a ground delay is in place, so that airlines could take the cost of delays into account on a more routine basis. There also may be advantages to having the market operate *ex ante*, rather than in real time, because of the large number of issues that airlines suddenly have to deal with when the FAA imposes a GDP.<sup>44</sup>

### *Potential Issues*

- *Efficiency:*
  - ▶ Uncertainty may be too great, and property rights insufficiently clear, for a market to work. GDPs are dynamic, with the FAA constantly revising EDCTs as weather and traffic conditions change. And ETMS learns about some flights (known as pop-ups) only after it has issued the GDP and assigned EDCTs.

---

<sup>42</sup> For an excellent discussion of the spot market idea, see Kevin Neels, "Pricing-Based Solutions to the Problem of Weather-Related Airport and Airway System Delay," *Air Traffic Control Quarterly*, Vol. 10 (3), 2002.

<sup>43</sup> Ball, Donohue and Hoffman, *op cit.*

<sup>44</sup> See Neels, *op cit.*

- ▶ Considering the relatively small number of planes that would be arriving at a given airport at a given time, the market may be too thin to yield a market clearing price.
- *Investment:* Airlines would have to make a significant investment in new systems to support the buying and selling of slots on a spot basis. Thus, it might make sense to introduce a spot market only after there is a primary and secondary market in slots.
- *Equity:*
  - ▶ Small communities may object for fear that their flights would be disproportionately affected. However, many communities have mainline as well as regional service. Moreover, small communities often have connections to more than one hub; thus, if one carrier chose to shift delays to its regional partner, a competing carrier could gain an advantage by following a different strategy.
  - ▶ FAA currently makes reasonable accommodations for general aviation under ground delays, and a spot market would probably need to do the same lest GA view it as discriminatory.
- *Controller workload:* Controllers may complain that a spot market would introduce unpredictability and chaos. But the current CDM process is unpredictable, and that does not interfere with controllers performing their job. It should be possible to design a spot market that is sufficiently transparent to satisfy controllers.
- *Gaming:* Airlines may be able to employ strategic scheduling to gain valuable rights to sell in the aftermarket. However, if the spot market operates only during ground delays, then carriers would have to operate their “strategic schedule” on many days when no such market materialized, which is probably not an economic proposition.

#### *Assign GDP Slots Based on Aircraft Size*

Instead of assigning EDCTs (slots) on a first-come, first-served basis, the FAA might want to use a criterion that offers some policy benefits, such as aircraft size (or number of passengers). Giving priority to larger aircraft would reduce the number of hours of delay endured by passengers—potentially by a significant amount, according to experts at DOT’s Volpe Center.

The basic flight plan information that airlines file with the FAA contains information on aircraft type and number of people on board, among other things. Thus this approach should be relatively easy to implement—either on a stand-alone basis or as part of a spot market.

#### *Potential Issues*

- The smallest aircraft flights could get pushed to the bottom of the list repeatedly throughout a ground delay. Thus, there may need to be some limit on the number of times that could happen.

- As a supplement to the basic spot market, this approach may be unnecessary because the spot market will itself favor flights on large aircraft.
- As part of a spot market, this approach would likely reduce the incentive for gaming by making it more expensive to schedule flights purely in the hopes of being able to sell the slot. However, if concerns about gaming are overstated, the payoff may be limited.
- This approach could complicate the operation of a spot market. Any sort of flight priority system has to have time as a dimension, and EDCTs are inherently dynamic based on changing demand and weather conditions.

### *Non-Interruptible Service Rights*

Under the current model, where the FAA uses ground delays and airborne holding to maintain safety, the system delivers what might be thought of as “interruptible service.” Under this proposal, in exchange for an additional payment, the FAA would provide a limited number of aircraft operators the equivalent of “non-interruptible” service to a particular airport during a given time period. For example, taking into account IFR capacity and other factors, the FAA could offer a certain number of operators a guaranteed arrival at O’Hare between 8 am and 8:30 am.<sup>45</sup> These guaranteed positions could be allocated through an auction or other market mechanism.

This approach could be implemented even at airports that are already slot-controlled. For example, at LaGuardia, current slot holders would bid for the right to guaranteed slots. Under this approach, incumbent slot holders could not complain that the auction was unfair: if they opted not to participate, they would still have a slot—just not a guaranteed slot.<sup>46</sup>

---

<sup>45</sup> The FAA would have to determine the exact dimensions of this kind of service—*i.e.*, would it provide non-interruptible service only at the arrival or departure airport, or would the guarantee of service extend to all parts of the flight (departure airport, arrival airport and en route system)?

<sup>46</sup> The money raised by such an option could be used to fund capacity expansion only (capital only or capital and operating costs). If current delays are deemed to be a significant threat to safety, the FAA could implement this provision via an interim final rule. Precedents include FAA’s response to the controllers’ strike in 1981, the “jawboning” of airlines operating at O’Hare to reduce the number of flights, and overflight fees. Two of these were done via an interim final rule—in one case (overflight fees) to meet a new statutory requirement, and in another (controllers’ strike) to address a short-term safety threat.

## IV. NEXT-GENERATION AIR TRANSPORTATION

The air traffic system will undergo profound changes in the coming years as it moves from ground-based radar to satellites and cockpit controls. This fundamental shift represents a tremendous opportunity: the history of network industries is the story of how technological change has made competition possible where it wasn't before. At the same time, the transition represents a risk. As discussed in Section I, the FAA still has not been able to bring large-scale modernization to the ATC system. If anything, the federal government's proposed Next Generation Air Traffic System program (NextGen) will pose greater challenges.

This section looks at how to facilitate the transition to a next-generation air traffic system that will provide stronger incentives for efficiency. First, I consider how new technology will affect the potential for markets and competition. Most of the analysis of next-generation technology has focused on what it will mean for airspace capacity and controller productivity; there has been little examination of the implications for competition. Next, I examine the federal government's program to move to a next-generation system: I raise concerns about the current approach to NextGen and offer some suggestions for making it more market-oriented.

### A. The Potential for Competition in a Next-Generation Air Transportation System

New technology will allow for two broad changes in the current, highly centralized, monopoly model of ATC. First, to some unknown degree, the essential function of aircraft separation will shift from the ATC provider (controllers on the ground) to pilots in the aircraft. Second, many of the other functions now performed by a monopoly ATC system will shift to third-party providers. Both of these changes increase the potential for competition and market incentives.

#### *Aircraft Separation*

Purely from a technical standpoint, experts believe it will be possible for properly equipped aircraft to self-separate in the oceanic and much of the en route environment. In theory, self separation will eliminate the need for controllers, much as telephone switching technology eliminated the need for switchboard operators. However, complete reliance on self separation would require aircraft to have a great deal of very expensive equipment on board, leading many experts to question whether it will ever be cost effective.

The most likely scenario is that much but not all of the control will shift to the aircraft: thus, aircraft will self-separate under the supervision of controllers in most airspace, with controllers actively managing the process in complex airspace. Self separation is many years off, however, and it will come about gradually, probably beginning in the highest altitude air space.

What, then, will this mean for competition? Most experts believe that aircraft separation in the terminal airspace will remain a local monopoly: that is, safety will dictate that an ATC provider coordinate takeoffs and landings, and it will be most efficient to have just one provider. But the same provider need not serve all terminal areas, which opens the door to additional *ex ante* competition (*i.e.*, competition beyond what exists now in the form of contract towers).

Aircraft separation in en route airspace will be more conducive to competition—at least in theory. In an area as large as the United States, one could have regional monopolies and award fixed-term contracts competitively. Alternatively, a common infrastructure of equipment and data could serve more than one provider, with subscriber groups segregated in terms of airspace.

### *Equipment and Applications*

With next-generation technology, many of the functions now performed by the centralized, monopoly ATC system can shift to third-party providers, which will facilitate competition and use of market incentives. This is analogous to what happened in telecom, when the provision of services and equipment traditionally reserved for AT&T was opened up to competition. Most next-generation technologies are networked services, such as data communications and precision routings. In some cases, the government may want a single-source provider—*e.g.*, for safety reasons, it makes sense for all aircraft operators to get the same weather information. But in most cases, it will be preferable—and should be possible—to have competing providers.

Moreover, as Andy Steinberg concluded, it should be possible in many cases for providers to transact directly with users to determine the types, level and price of the service or equipment to be provided.<sup>47</sup> That arrangement provides the best incentives for efficiency. If users pay the provider directly, the market will determine where and when deployment of the service or equipment makes sense. The provider will also have an incentive to subsidize equipage insofar as the benefits from expanding the size of the network of users offset the costs.

In other cases—most likely, with equipment—the ATO (or an airport) rather than the aviation user may be the logical customer. For example, the ATO recently issued a contract to a private consortium to develop and install ADS-B ground equipment. That is a legitimate role for government: ADS-B represents physical infrastructure that might not otherwise get built.

That said, the government need not own and operate ground equipment as it has traditionally done. Because next-generation equipment will provide data in digital form, the ATO can simply lease the service—in effect, buying a stream of data that will go to controllers and (equipped) aircraft. This arrangement, which the FAA adopted in the ADS-B contract, is efficient because it internalizes the costs and benefits: the consortium will have an incentive to build and install the equipment properly because it will also own and operate it.

Like Steinberg, I envision that local airports will play an expanded role in supplying services in a next-generation system. A number of new technologies have airport-specific applications, and airports will have an incentive to use them to enhance the efficiency and dependability of their operations. The airport operator would most likely serve as an intermediary between a vendor and airport users. But the airport could have a direct incentive to subsidize equipage, particularly if it could recover the cost through its rates and charges.

---

<sup>47</sup> Andrew Steinberg, “A Proposed Approach to the Management of the Next Generation Air Transportation System,” undated discussion draft.

### *Performance Contracts and Property Rights*

Next-generation technologies will facilitate the use of market mechanisms in other respects. For example, using four-dimensional trajectories that pinpoint an aircraft's exact position, the ATO will be able to "contract" with pilots to land at a given time; pilots that meet their contracts can be given priority landing times.<sup>48</sup> More generally, precision technologies allow the ATO to set performance standards and let the aircraft operator figure out how best to meet them. Precision technologies will also make it easier to define the property rights to an air route or landing slot. That is the first step to allocating those resources through an auction or other market mechanism.

### *Implications for Government*

In sum, next-generation technology will not eliminate the need for an ATO-type provider. But its responsibilities will change, as controllers focus less on tactical separation and more on strategic management,<sup>49</sup> and as many other functions are assumed by third-party providers. Moreover, the ATO may face competition, although it seems likely that the ATO or something like it will be dominant for a long time. *Ex ante* competition between regional providers—which is possible even now—seems unlikely. *Ex ante* competition at the terminal level seems more likely, but even there, economies of scope may limit the role of alternate providers.<sup>50</sup>

There are two key implications for government. The prospect of a next-generation system only strengthens the safety and efficiency rationales for moving the ATO out of the FAA. In terms of safety, the ATO will be a highly stressed organization as it undergoes profound technological change; separation of regulatory oversight will be critical to preserving safety margins. In terms of efficiency, a commercially oriented ATO would have greater incentive and ability to take advantage of markets and competition where they exist.

In addition to regulating safety, the government's other principal role will be to set standards—performance standards as well as technical standards to ensure that equipment is interoperable.<sup>51</sup> In addition, it may be helpful for the government to set the financial equivalent of technical standards. By making data on system costs transparent and widely available, the FAA could promote competition among services and equipment providers. (Other steps the government can take as part of NextGen are discussed in part C. below.)

---

<sup>48</sup> Researchers at University of California at Berkeley are studying the technical feasibility of such routing arrangements under a grant from NASA. "Grant Looks to Help Overhaul Air Traffic Control," *The Daily Californian*, September 11, 2007.

<sup>49</sup> This change in function has parallels in other network industries that have undergone deregulation. For example, following trucking deregulation, the traffic managers employed by shippers went from being green-eyeshade price-takers to entrepreneurial price-setters.

<sup>50</sup> In the UK, where contracts to manage towers are awarded competitively, the national service provider, NATS, holds the contracts at Heathrow and other large airports. This suggests that there are economies of scope in the provision of tower and non-tower services.

<sup>51</sup> Presumably, the government would license or certify qualified firms to supply specified infrastructure and services within a given region. Steinberg envisions that the FAA could do this using either its "other transactions" authority or its dormant statutory authority through rulemaking to certify "air navigation facilities."

## B. NextGen: The Current Path

The federal government's Next Generation Air Traffic System program was announced in 2004, in response to estimates that air traffic would double in two decades. NextGen is a collection of ongoing and new programs that is intended to triple capacity by 2025 at a cost of \$40-\$45 billion, including the cost of equipage. (That figure does not include the cost to maintain and modernize the existing system.) The details of how NextGen will work are the focus of a multi-agency planning effort overseen by the Joint Planning and Development Office (JPDO).

The FAA has taken several market-oriented steps in the context of NextGen, including the recent ADS-B contract: in addition to altering its traditional approach to infrastructure—from buying hardware to leasing a service—the FAA required bidders to put up a significant share of the financing in exchange for the right to sell related commercial services. Another positive step was the FAA's recent decision to approve a third-party provider, Naverus, to design customized RNP procedures—an activity that was traditionally the FAA's exclusive domain.

Despite these and other positive steps, the federal government's approach to NextGen raises real concerns. First, it is a highly ambitious program geared to “transformation” of the current system. And like the Big Bang, it would deliver most of the benefits all at once near the end of a transition measured in “epochs,” not years.<sup>52</sup> Given its track record on modernization, one has to question whether the FAA is capable of carrying out such an ambitious makeover.

Much has been written about the problems of FAA modernization. Those problems largely reflect the faulty incentives discussed throughout this paper. But one proximate cause has been an overambitious agenda underscored by excessive faith in new technology. The failure of the Advanced Automation System was a direct result of unrealistic technical goals. And because it was terminated early and the benefits were back-loaded, the program produced little of value.

Second, the goal of a threefold increase in capacity—which is driving much of the cost of NextGen<sup>53</sup>—reflects political more than market forces. This goal is largely a response to the prospect of on-demand, small jet services: many in the aviation and aerospace industries want to see this phenomenon play out in the market without regard to infrastructure limitations.<sup>54</sup> And in keeping with its historic mission to promote aviation, the FAA sees its job as accommodating the maximum possible demand.

---

<sup>52</sup> Phase one of NextGen consists of core infrastructure technologies that will not provide immediate benefits to users: better location information (GPS), surveillance (ADS-B transmit), air-to-ground communications (digital radios and email exchange), and information sharing capability. Phase two would provide improved capabilities for precision navigation, advanced weather forecasting, wake vortex prediction and reduced separation in certain airspace. The final phase of NextGen includes technology for precise navigation and surveillance information (ADS-B receive) that would provide significant benefits for users.

<sup>53</sup> Conversation with Mark Hansen, July 25, 2007. Hansen is an engineering professor at the University of California, Berkeley, and leads Berkeley's research on ATC, most of it funded by NASA and the FAA.

<sup>54</sup> See Statement of Mark M. Hansen, *op cit*. Note that the industry's desire to accommodate market demand without regard to infrastructure limits, as Hansen characterizes it, is an oxymoron. Infrastructure is necessarily limited, and services should be priced accordingly; in theory, if demand for the services is high, users will be willing to pay for additional infrastructure.

Although it is only natural for industry participants to lobby for it, unlimited infrastructure should not be the government's goal.<sup>55</sup> This is particularly true here, where the delays cited to justify a huge increase in capacity are “self-inflicted”—*i.e.*, the predictable result of the government's own perverse system of charging for airway and runway usage. The question is: would (future) users want that level of expansion if they had to pay for it?

Third, the NextGen planning process—government scientists and engineers charged with figuring out what system users will need 20 years from now—is equally removed from market forces. Despite the JPDO's long-term time horizon, the group's perspective is technology-centric, with little consideration of how the market itself may change.<sup>56</sup> The JPDO's perspective is also government-centric: industry stakeholders play less of a role than they do in SESAR, the European equivalent to NextGen, and labor has almost no voice.

Lack of stakeholder involvement has been a chronic weakness of FAA modernization: the FAA has picked the wrong technologies in some cases because it failed to consult with airline-users, and in other cases, its exclusion of labor has undermined support even for the right technologies. The recently created NGATS Institute is intended to facilitate industry input, but the relationship is far from a partnership, according to aerospace industry officials.<sup>57</sup>

NextGen represents an immense coordination problem—one that involves aircraft operators of all types, airports and manufacturers, as well as the FAA and other federal agencies. The design of such a system needs to reflect customers' willingness to pay, the incremental costs of capacity, and a host of other factors that can't be determined through a hierarchical process. Although there is a role for a central planning authority, NextGen planning requires market signals at every turn.

Finally, although NextGen's success depends on aircraft owners making expensive investments in advanced avionics, the business case for those investments is weak. NextGen programs are sequenced and timed so as to yield savings to the FAA, but users see few benefits for many years. Internal FAA proposals, which assume that users will invest in equipment long before they see any benefits, are flawed: airlines are notorious for expecting investments to pay off quickly.

Moreover, U.S. airlines are understandably skeptical of FAA claims that new technology will increase system productivity (recall Figure 6, showing that productivity has been flat since 1982

---

<sup>55</sup> One government economist who deals with JPDO characterizes it as a group whose mission is to make the case for sufficient investment in aviation system capacity to ensure that the correct price for all services is zero.

<sup>56</sup> One economist I spoke with noted the seemingly implicit assumption that the FAA will remain a monopoly provider, which he compared to the mindset of telecommunications analysts prior to the breakup of AT&T.

<sup>57</sup> Aerospace Industries Association, “White Paper on Ensuring JPDO Success,” undated; available at: <http://www.aia-aerospace.org/issues/subject/subjectcfm>. The JPDO's lack of customer orientation extends to its relationship with the ATO. Several years ago, ATO-head Russ Chew and a senior JPDO official each briefed a National Academy of Sciences workshop on the JPDO. (JPDO reports to the head of ATO and the FAA Administrator.) Both Chew and the JPDO official displayed organization charts; remarkably, the JPDO chart did not include the ATO, and the ATO chart likewise omitted the JPDO.

despite the \$45 billion spent on modernization).<sup>58</sup> And, in fact, the FAA has already backed off of its estimates of what ADS-B could save by allowing the agency to turn off expensive radars—estimates that drove its own business case for ADS-B. The FAA now says that it will have to maintain many of the radars indefinitely to protect safety and homeland security.

In sum, the federal government’s top-down, techno-centric, Big-Bang approach to NextGen seems to embody much of what is wrong with the current ATC system. Absent some fundamental reform of the structural problems discussed earlier, it seems likely that NextGen will go down the same troubled path as modernization. Albert Einstein’s definition of insanity—continuing to do the same thing over again and expecting a different outcome—comes to mind.

### **C. A More Market-Oriented Path to NextGen**

To make NextGen a more market-oriented program, there are some steps the government might take—and a few it should avoid.

#### ***Vision: Targeted Improvements that Users Want and Will Pay For***

As an alternative to the current vision, the federal government could treat NextGen as a way to develop and deliver targeted improvements in specific regions that users want and are willing to pay for.<sup>59</sup> This more modest vision implies a focus on adaptation as well as transformation. A more incremental approach would mitigate many of the concerns with the Big Bang vision discussed above, including the equipage challenge. And by providing benefits to users in the relatively near term, it would yield insights into longer-term questions such as how much of the aircraft separation technology should go in the cockpit and how much should stay on the ground.

An example of this incremental approach is the FAA’s plan to deploy ADS-B on an accelerated basis in the Gulf of Mexico. Some 650 helicopters make about 7,500 trips a day to more than 5,000 offshore oil and gas platforms. But the absence of radar offshore means that most of the helicopters can’t communicate with or be seen by controllers. Owners of helicopters equipped for ADS-B will see immediate benefits and the FAA will gain valuable experience as well.

In other places where the FAA has agreed to install ground equipment, carriers are aggressively investing in next-generation technologies that can improve their operations.<sup>60</sup> For example, package carrier UPS, which needs to land hundreds of flights at its Louisville hub in a hurry each night, is spending heavily to equip its aircraft to use ADS-B-transmit as well as the more advanced ADS-B-receive technologies. ADS-B, together with a custom approach pattern developed by a Phoenix-based firm, allows UPS freighters to self-separate and make “continuous

---

<sup>58</sup> One specific issue is that the airlines don’t trust the FAA to deploy the complementary ground equipment, as a result of several bad experiences. For example, U.S. airlines invested in FANS 1 equipment to allow for more efficient trans-Pacific operations in the early 1990s based on FAA assurances that it would deploy compatible ATC equipment. The FAA has yet to make good on those assurances.

<sup>59</sup> Statement of Mark M. Hansen, *op cit*.

<sup>60</sup> Matthew L. Wald, “For Airlines, Hands-On Air Traffic Control,” *New York Times*, September 5, 2005

descents” into the airport, saving fuel (50-100 gallons per flight) and time (pilots can space their planes more precisely than controllers looking at radar can). As another example, Alaska Airlines is using RNP routes to land aircraft in Alaskan airports under visibility conditions that previously would have forced the flight to be delayed or diverted to another airport.

The common denominator among these examples is “benefits capture”: because a carrier’s operations at a specific location are highly concentrated, it can capture benefits that more than offset the cost of equipping its aircraft and developing the necessary procedures. The phenomenon need not be limited to a single carrier. For example, NavCanada is installing ADS-B over the Hudson Bay—an area not served by radar—because users asked for it and agreed to pay the cost; ADS-B coverage will allow high-value international flights to receive real-time weather data and avoid some of the delays associated with the wide separations now required.

These examples represent low-hanging fruit: it would be harder to get the carriers that fly into Louisville during the day to equip for ADS-B because the benefits to any single carrier might not offset the costs. Nevertheless, the examples point up how the FAA can accelerate near-term opportunities to provide benefits to system users. In addition to targeted deployment of ground equipment, a key contribution is regulatory flexibility—certifying private firms to perform functions that are not inherently governmental, and allowing experimentation with self separation. In short, the FAA can help by getting out of the way, where appropriate.

It’s worth noting that user fees *would have* facilitated projects such as Louisville and the Gulf of Mexico: if the FAA were a fee-for-service provider, installation of ADS-B ground equipment would have been a business decision that the provider and users arrived at routinely, as in the Hudson Bay example. But tax financing precludes any such direct transaction, and the alternative—persuading the FAA—takes years, as UPS and the gulf helicopter owners can attest.

Given the severity of flight delays, there should be many opportunities for the FAA to provide targeted improvements that users want and are willing to pay for. Airports are a logical source of opportunities. They are well positioned to organize a critical mass of users in support of a local or regional initiative, thus reducing transaction costs. And, as discussed earlier, airports will have an incentive to subsidize equipage under some circumstances, which will reduce the direct costs to users. DOT could encourage airports to assume more responsibility for next-generation infrastructure through its Rates and Charges Policy or by freeing federal funds from the Airport Improvement Program or the passenger facility charges.<sup>61</sup>

The FAA can encourage equipage more directly as well, by giving equipped aircraft preferential treatment—*e.g.*, access to preferred airspace or landing slots. It can also leverage the procurement process, as it did with the ADS-B contract, where bidders were evaluated in part on the basis of how they proposed to promote equipage.

---

<sup>61</sup> See Andrew Steinberg, *op cit.*, p. 16.

### “Fast Lane” for Aircraft

Initiatives such as those in Louisville, Alaska and the Gulf of Mexico create the equivalent of a “fast lane” for properly equipped aircraft, as an FAA manager in Houston who is working on the gulf project described:

We want to establish what will be like an HOV lane for anybody that is equipped. [Then] they wouldn’t have to be with the rest of the airplanes and incur the kinds of delays and altitude restrictions that everyone else does.<sup>62</sup>

This is a useful metaphor to describe the more incremental vision of NextGen proposed here. The current, Big-Bang approach delivers most of the benefits only after the vast majority of users have equipped. But it might be possible for equipped aircraft to take advantage of next-generation technologies much sooner in selected airspace.

The threshold question is whether a fast lane is feasible—economically as well as technically—on a broad scale. Ideally, it would operate nationwide in high-density terminal airspace and in en route airspace above a certain altitude or along specific routes.

From a technical standpoint, creation of a fast lane requires the capability to segregate traffic. The FAA is already operating the equivalent of fast lanes—called Q routes—for approved aircraft and flight crews in certain en route airspace. In contrast to conventional jet routes, which are defined by ground-based navigation aids, a number of Q routes use RNP procedures and on-board, satellite-based navigation equipment. Creating a fast lane in crowded terminal airspace would be more challenging, and the redesign of complex airspace could spur NIMBY opposition, as it has in New York. But such airspace needs to be redesigned at some point, and next-generation technologies can identify routes that minimize noise and emissions impact.

Economic feasibility is as important as technical feasibility. A recent analysis of the economics of NextGen at the 35 largest Operational Evolution Plan (OEP) airports suggests that a fast lane might be feasible. The key is that the largest airports are relatively concentrated. The analysis concluded that, if traffic could be segmented, the relatively small set of operators that use the busiest and most congested airports could capture benefits in excess of the costs of equipage.<sup>63</sup>

Tables 1 and 2 in the Appendix lend support to this conclusion. Table 1 shows the share of operations at the largest airports that are accounted for by the biggest operators. The key point is that the top two dozen to three dozen operators account for most of the operations at the 30-40 largest airports. Table 2 shows the identity of the top operators. What’s notable is that the legacy carriers and their regional partners—whose equipage decisions would presumably be linked—make up much of the list, along with the major low cost carriers, the large integrated cargo carriers, and a few specialized users such as Netjets. In short, equipage by a relatively

---

<sup>62</sup> Jennifer Oldham, “Carpool Lanes for Airplanes?,” *Los Angeles Times*, June 11, 2007.

<sup>63</sup> Frank Berardino, “GRA Paper Regarding the Impacts of NextGen”, prepared by GRA, Incorporated for the Science and Technology Policy Institute (STPI), August 1, 2007.

limited number of aircraft operators would serve to cover most operations at the 30-40 largest airports.

### *Governance*

Although it may be appropriate to have a central planning authority such as the JPDO, NextGen needs to be more accountable to aircraft operators and other stakeholders. Europe's approach is suggestive: stakeholders participate extensively in planning for the next-generation system through the SESAR Consortium, and they sit on SESAR's Executive Committee, which controls major program decisions.<sup>64</sup>

One proposal along those lines is to put NextGen under the control of a stakeholder board with its own, independent staff. Such a board would be able to assess whether individual components of NextGen offered enough user benefits to justify their cost and, as a last resort, set deadlines for aircraft to be suitably equipped. The Senate's reauthorization bill includes a stakeholder board, but it reportedly does not provide for an independent staff or a broad set of stakeholders.<sup>65</sup>

The Senate bill also creates an associate FAA administrator position to lead NextGen, effectively replacing the inter-agency JPDO. This provision no doubt reflects the frustration that Boeing and other manufacturers have repeatedly expressed with the JPDO. Boeing believes that there needs to be a single FAA official in charge of NextGen—someone with “the necessary position, power, budget authority and program control to successfully execute [the] transition...”<sup>66</sup>

NextGen crosses organizational divisions within FAA, including airports and safety oversight, as well as ATO. Thus, there is something to be said for giving a new associate administrator responsibility for the program. However, that step alone will not resolve deeper questions about NextGen budget and control. Moreover, the Senate proposal would severely undercut the ATO, which views NextGen as a way to fundamentally restructure the provision of ATC—*i.e.*, to reinvent itself. In sum, the Senate proposal seems ill-advised; a better solution would be to let the JPDO finish its work set and then either close it down or incorporate it into the ATO.

### *Financing and Procurement*

The need for efficient pricing of air traffic services has been the major theme of this paper. Although there are political impediments to the economist's ideal—marginal cost pricing of the entire ATC system—it may be feasible to introduce efficient pricing just for new services. The analogy is to toll roads: although voters have systematically rejected proposals to toll existing roads, they have accepted tolls on new roads or new lanes on existing roads.

---

<sup>64</sup> See: [http://www.sesar-consortium.aero/mediasandfiles/Flash/01\\_phase/ExecCommit.swf](http://www.sesar-consortium.aero/mediasandfiles/Flash/01_phase/ExecCommit.swf)

<sup>65</sup> Reason Foundation, ATC Reform News, Issue No. 45, June 2007.

<sup>66</sup> Neil Planzer, “Will There Be a Next Generation Air Traffic Control System?,” Notes from speech to a technical symposium hosted by the FAA, NASA and Air Traffic Control Association, May 2007.

Among other benefits, user fees could pave the way for FAA borrowing authority. Many argue that the FAA needs a way to fund the NextGen capital cost via revenue bonding, and the Administration itself included a modest proposal in its FAA bill.

In addition, it might make sense to have the private sector participate in financing NextGen. This would improve incentives for the investment in and use of new services and could make additional funds available to expedite implementation. The recent ADS-B contract is evidence of industry's willingness to help finance NextGen.<sup>67</sup>

However, borrowing authority and private financing make sense only if the incentives are right. If the incentives are wrong, the outcome will be disappointing or even perverse, as the discussion below—of three much-talked-about proposals for financing NextGen—illustrates.

### *Direct Borrowing Authority*

The logic of giving the FAA statutory borrowing authority is that there are large, “lumpy” investments that should be made up front, so that users benefit sooner rather than later. By borrowing money in the bond market, the FAA would have predictable, stable levels of funding, leading to more efficient capital expenditure decisions. In addition, borrowing authority would shift the funding burden from current users to future users, which is appropriate for long-term capital investments. Finally, the transition to borrowing produces a one-time period of reduced revenue needs, which would give the airlines a window of cost savings.<sup>68</sup>

However, borrowing authority also carries significant risk. The Administration's proposal was premised on a shift to user fees that now appears unlikely.<sup>69</sup> Giving the FAA access to the bond markets before Congress has solved its structural problems would have perverse consequences—in effect, “feeding the beast.” Moreover, ATC reformers have viewed borrowing authority as the carrot in exchange for which Congress would have to agree to user fees. If the FAA gets borrowing authority while it is still tax-financed, the prospects for user fees will diminish.

In sum, borrowing authority makes sense only if it is tied to efficient pricing. DOT's Inspector General summed up the risk succinctly: “In the absence of meaningful reform at FAA, the one-time influx of cash may simply allow inefficient investments to continue. In view of this, borrowing authority could saddle future users of the ATC system with a significant debt without seeing any real benefits.”

---

<sup>67</sup> Booz Allen Hamilton is looking at alternative business models for procuring key NextGen components.

<sup>68</sup> “FAA's Financing Proposal,” Statement of the Honorable Calvin L. Scovel III, Inspector General, Department of Transportation, before the Subcommittee on Aviation, U.S. House Committee on Transportation and Infrastructure, March 21, 2007, p. 18.

<sup>69</sup> Federal budget experts typically maintain that bonding would require a dedicated funding source in the form of user fees, as opposed to taxes, which are subject to the vicissitudes of Congress and the federal budget process. However, Wall Street officials have indicated that user fees are not necessarily essential, and that it would be possible to sell bonds based on anticipated tax revenue.

Indirect Borrowing Authority—Privatization of Procurement (F&E)

At the urging of several U.S. airlines, former Senate Commerce Committee Chairman Ted Stevens last year proposed to spin off the FAA's Facilities and Equipment (F&E) division as a legally separate organization known as the "Next Generation ATC Procurement Authority." The privatized organization would be charged with developing and deploying the next-generation system. Toward that end, it could impose user charges and borrow money in the capital market. Proponents acknowledge that this approach, which can be thought of as an "F&E Corporation," is a way to get around federal budget constraints and restrictions on borrowing.<sup>70</sup>

An F&E Corporation, which represents an indirect approach to FAA borrowing, poses the same risk as direct FAA borrowing authority: removing the agency's budget constraint without treating the underlying problems that have plagued modernization would "feed the beast." However, the privatization of F&E would be even more perverse because it would separate the ATO's "head" (procurement) from its "body" (operations).

To elaborate, although the ATO contracts out much of the actual development of software and equipment, F&E performs key functions internally, including determining system needs and requirements. F&E was effectively separated from Operations in the early 1980s, and former FAA officials believe that contributed to the failures of modernization. The key is coordination and communications, according to George Donohue: ATC equipment is highly customized; F&E engineers and Operations staff need to work closely together to get the "interface" right.<sup>71</sup>

Russ Chew shared that view and made it a priority to reintegrate F&E and Operations, by giving individual business units (*e.g.*, Terminal Operations) the lead on research and acquisitions to meet their needs. He summarized the weakness of "stovepiping" this way: "It's kind of like asking your neighbor to buy a stereo for you. You're not going to like what you get."<sup>72</sup>

Chew's emphasis on reintegrating F&E and Operations is consistent with economic theory and research on the alternative ways firms structure their activities, from complete reliance on spot markets to full vertical integration. That work emphasizes the importance of transaction costs, including the cost of discovering relevant prices and negotiating and enforcing contracts. The key insight is that organization matters.<sup>73</sup>

Although the ATO does not operate in a competitive environment, it is reasonable to assume that it has adopted the organizational structure that best meets its needs. Thus, the fact that the ATO has opted to keep its F&E function in-house—and, in fact, has recently reintegrated that function

---

<sup>70</sup> The concept of an F&E Corporation was considered—and rejected—by both the first Bush Administration and the Clinton Administration. However, the FAA reportedly incorporated the idea in a draft legislative proposal it sent to OMB to review.

<sup>71</sup> Telephone interview with Donohue, March 7, 2006. Donohue, an engineering professor at George Mason University, was FAA Assistant Administrator for Research and Acquisitions from 1994 to 1997.

<sup>72</sup> Govexec.com, Daily Briefing, November 18, 2003.

<sup>73</sup> Oliver E. Williamson, *Markets and Hierarchies: Analysis and Antitrust Implications*, Free Press (1975)

more closely with Operations—suggests that there are efficiencies from vertical integration. The spinoff of F&E that Sen. Stevens proposed would eliminate these important efficiencies.<sup>74</sup>

### Industry Consortium

Michael Scott, a former Treasury official who is now with Bank of America, has suggested that an industry consortium could finance and deploy the complete, integrated NextGen system under a service contract with the ATO, which would remain a government entity. ATC users would serve on the board of the consortium to provide customer input and feedback.

Scott's goal is to bring NextGen capacity increases online as rapidly as possible and to reduce the financing costs to "near treasury" interest rates. He envisions a single consortium that would finance and deploy all of NextGen. In fact, the consortium might even buy up next-generation equipment now owned by the FAA—in effect, privatizing the physical assets.

Scott's proposal is a very useful contribution to the debate and has drawn considerable interest. An industry consortium could accelerate NextGen and inject market discipline. Moreover, having users on the board would help address the limits of the current governance model.

But the approach has serious drawbacks in its current form. First, Scott wants the consortium to develop a complete, integrated NextGen system because the more essential the service—and the less chance the FAA would cancel the contract—the higher the bond ratings. But, as discussed earlier, a Big Bang approach is probably not desirable. Nor is it feasible. Realistically, it would be impossible for the FAA to write a contract to develop NextGen. The task is too complex.

In addition, Scott's proposal replaces one monopoly with another. He believes the consortium will have an incentive to be efficient because it will own the asset. That may be true initially; but the incentives will change over time if, as he envisions, the same entity maintains the NextGen "monopoly."<sup>75</sup> (If the users were owners, that might not be a problem.)

Finally, there would be political resistance to what would be seen as partial privatization.

In sum, some private sector financing of NextGen makes sense. But if the goal is private sector financing to the extent that Scott envisions, it would probably be better to spin off the ATO altogether (*i.e.*, to create an independent government corporation, a user-owned cooperative or a private provider). That would avoid some of the problems of his proposed consortium and would be only slightly less politically difficult to accomplish.

---

<sup>74</sup> Dorothy Robyn, "Proposal to Spin Off the FAA's F&E Activities: A Preliminary Analysis of Potential Unintended Consequences," Prepared for the DOT Office of the Inspector General, October 30, 2006.

<sup>75</sup> Scott does not even envision the consortium being selected through a competition. Rather, in his view, the entire industry would agree on an approach and financing mechanism and take it to the FAA (or Congress) for approval. But that "sole-source" approach is not inherent. The FAA could select the consortium on a competitive basis, much as it selected the ADS-B contractor competitively.

### *Spectrum Auctions as a Way to Subsidize Equipage*

The NextGen transition is lengthy in part because the FAA anticipates that many general aviation users will be slow to equip. If the federal government could accelerate equipage by those late adopters, NextGen could deliver benefits sooner to the early adopters and the FAA itself.

One idea would be to take advantage of the improvements that NextGen will bring in terms of FAA spectrum efficiency. The FAA currently uses a great deal of radio frequency (RF) spectrum and uses it very inefficiently. ADS-B will allow the FAA to turn off many of its radars, thus freeing up a potentially significant amount of this spectrum—spectrum that is located in a very desirable part of the RF band. In theory, it would be possible to auction off the spectrum that would be freed up in advance and use some of the auction revenue to subsidize equipage by late adopters.

To be sure, there are impediments to this kind of a “grand bargain,” and it may not be feasible in practice. Among other things, the FAA will have to agree to give up spectrum (federal agencies typically hoard spectrum because they have no incentive to do otherwise). And because spectrum does not belong to individual agencies, Congress will have to agree to let some of the proceeds go to accelerate NextGen. But there is a recent and direct analogy in the grand bargain that allowed Congress to accelerate the digital television (DTV) transition, which will free up valuable spectrum in the 700 MHz band.

To elaborate, the impediment to the DTV transition was the concern that consumers who still receive their TV signals over the air would be harmed when broadcasters were forced to abandon the 700 MHz spectrum where their analog operations are located. To address that concern, Congress instructed the FCC to auction off the 700 MHz spectrum a year before the actual transition and use some of the proceeds to subsidize the purchase of converter boxes for affected consumers.

In sum, spectrum is the FAA’s most valuable asset, and NextGen should serve to free some of it up for other purposes. Thus, the potential for a win-win outcome exists. The Department of Commerce is leading a Bush Administration effort to increase the efficiency with which federal agencies use spectrum. This could be a highly visible pilot program.

## **APPENDIX**

**Table 1: Airport Shares of Operations by Top Operators**

Airport Code	Airport Name	40 Airports 36 Operators	30 Airports 26 Operators	Difference from 40 to 30
ATL	The William B Hartsfield Atlanta Intl, GA	95.6%	94.3%	1.3%
ORD	Chicago O'Hare Intl, IL	93.3%	92.9%	0.4%
DFW	Dallas/Fort Worth International, TX	94.6%	92.4%	2.2%
LAX	Los Angeles Intl, CA	82.3%	80.6%	1.6%
IAD	Washington Dulles International, VA	78.9%	75.3%	3.6%
DEN	Stapleton Intl, CO	85.2%	70.4%	14.8%
IAH	Houston Intercontinental, TX	93.9%	91.0%	2.9%
MSP	Minneapolis-St Paul Intl/Wold-Chamberlai, MN	88.5%	86.9%	1.5%
DTW	Detroit Metropolitan Wayne County, MI	92.4%	90.7%	1.7%
PHL	Philadelphia Intl, PA	90.2%	70.5%	19.7%
PHX	Phoenix Sky Harbor Intl, AZ	89.9%	85.4%	4.5%
CVG	Cincinnati/Northern Kentucky Internation, KY	90.2%	88.6%	1.6%
CLT	Charlotte/Douglas Intl, NC	89.4%	68.4%	21.0%
LAS	Mc Carran Intl, NV	77.6%	74.2%	3.4%
EWR	Newark Intl, NJ	90.0%	88.6%	1.4%
BOS	General Edward Lawrence Logan Intl, MA	80.2%	71.4%	8.8%
LGA	La Guardia, NY	90.3%	75.9%	14.4%
MEM	Memphis Intl, TN	86.9%	84.7%	2.3%
SLC	Salt Lake City Intl, UT	88.3%	84.2%	4.1%
MIA	Miami Intl, FL	62.4%	59.7%	2.7%
MCO	Orlando Intl, FL	82.9%	77.9%	5.0%
JFK	John F Kennedy Intl, NY	75.3%	52.9%	22.4%
SFO	San Francisco Intl, CA	84.7%	82.5%	2.2%
SEA	Seattle-Tacoma Intl, WA	93.3%	92.1%	1.1%
CYYZ	Toronto/Lester B Pearson In, ON	56.6%	55.0%	1.6%
FLL	Fort Lauderdale/Hollywood Intl, FL	61.3%	53.4%	7.9%
BWI	Baltimore-Washington Intl, MD	84.1%	78.9%	5.2%
STL	Lambert-St Louis Intl, MO	84.4%	82.5%	1.9%
MDW	Chicago Midway, IL	57.9%	52.9%	5.0%
DCA	Ronald Reagan Washington National, DC	94.7%	82.7%	12.1%
PIT	Pittsburgh International, PA	79.1%	62.9%	16.2%
CLE	Cleveland-Hopkins Intl, OH	81.8%		
TPA	Tampa Intl, FL	70.7%		
PDX	Portland Intl, OR	81.6%		
RDU	Raleigh-Durham International, NC	74.0%		
OAK	Metropolitan Oakland Intl, CA	83.6%		
IND	Indianapolis Intl, IN	72.1%		
SAN	San Diego Intl-Lindbergh Fld, CA	89.2%		
HNL	Honolulu Intl, HI	17.3%		
BNA	Nashville International, TN	69.9%		
MKE	General Mitchell International, WI	38.8%		

Source: GRA analysis of FY 2005 11 Months of ETMS departures by airport and operator

**Table 2: Operator Shares at Top 30 and 40 Airports**

Operator Name	Airline Code	Total ETMS Departures	40 Airport Departures	40 Airport Percent	30 Airport Departures	30 Airport Percent	Difference in % 40 and 30 Airports
Southwest Airlines	SWA	941,243	523,743	55.6%	374,559	39.8%	15.8%
American Airlines	AAL	766,920	589,488	76.9%	555,432	72.4%	4.4%
Delta Airlines	DAL	678,215	533,396	78.6%	497,160	73.3%	5.3%
American Eagle	EGF	554,179	325,590	58.8%	285,082	51.4%	7.3%
United Airlines	UAL	514,056	428,233	83.3%	398,209	77.5%	5.8%
Northwest Orient Airlines	NWA	507,166	390,568	77.0%	356,070	70.2%	6.8%
Sky West Aviation	SKW	473,141	263,749	55.7%	243,804	51.5%	4.2%
USAir	USA	445,573	356,121	79.9%	334,442	75.1%	4.9%
Britt Airways	BTA	406,568	265,309	65.3%	204,799	50.4%	14.9%
Comair	COM	360,007	232,984	64.7%	218,664	60.7%	4.0%
Continental Airlines	COA	343,628	270,080	78.6%	242,297	70.5%	8.1%
Mesa Aviation Services	ASH	300,834	191,544	63.7%	176,044	58.5%	5.2%
Atlantic Southeast Airlines	CAA	289,036	159,900	55.3%	154,058	53.3%	2.0%
Chautauqua Airlines	CHQ	228,626	142,438	62.3%	119,947	52.5%	9.8%
Express Airlines	FLG	222,957	132,195	59.3%	119,990	53.8%	5.5%
Mesaba Aviation	MES	194,671	102,216	52.5%	100,230	51.5%	1.0%
Federal Express Corporation	FDX	194,239	133,938	69.0%	103,275	53.2%	15.8%
Netjets Aviation	EJA	192,666	45,423	23.6%	38,113	19.8%	3.8%
America West Airlines	AWE	191,994	162,901	84.8%	150,143	78.2%	6.6%
Airtran Airways	TRS	171,960	137,814	80.1%	128,237	74.6%	5.6%
Alaska Airlines	ASA	165,865	99,911	60.2%	78,602	47.4%	12.8%
Air Wisconsin Airlines	AWI	165,624	103,134	62.3%	94,594	57.1%	5.2%
Horizon Airlines	QXE	164,688	85,425	51.9%	55,414	33.6%	18.2%
Atlantic Coast Airlines	IDE	156,567	110,067	70.3%	100,443	64.2%	6.1%
Air Canada	ACA	138,803	85,974	61.9%	83,579	60.2%	1.7%
Trans States Airlines	LOF	132,762	87,297	65.8%	82,613	62.2%	3.5%
Piedmont Airlines	PDT	130,384	69,397	53.2%			
United Parcel Service	UPS	117,418	35,592	30.3%			
Flight Options	OPT	104,818	20,119	19.2%			
Jetstream International Airlines	JIA	102,553	65,785	64.1%			
Ameriflight	AMF	100,368	28,427	28.3%			
Jetblue Airways	JBU	98,151	73,295	74.7%			
US Check Airlines	USC	95,976	26,320	27.4%			
Colgan Air	CJC	76,684	33,977	44.3%			
Frontier Airlines	FFT	70,775	61,338	86.7%			
Airborne Express	ABX	68,566	15,851	23.1%			
<b>All</b>		<b>17,117,798</b>	<b>7,669,858</b>	<b>44.8%</b>	<b>6,622,697</b>	<b>38.7%</b>	

Source: GRA Analysis of FY2005 ETMS data (11 months).